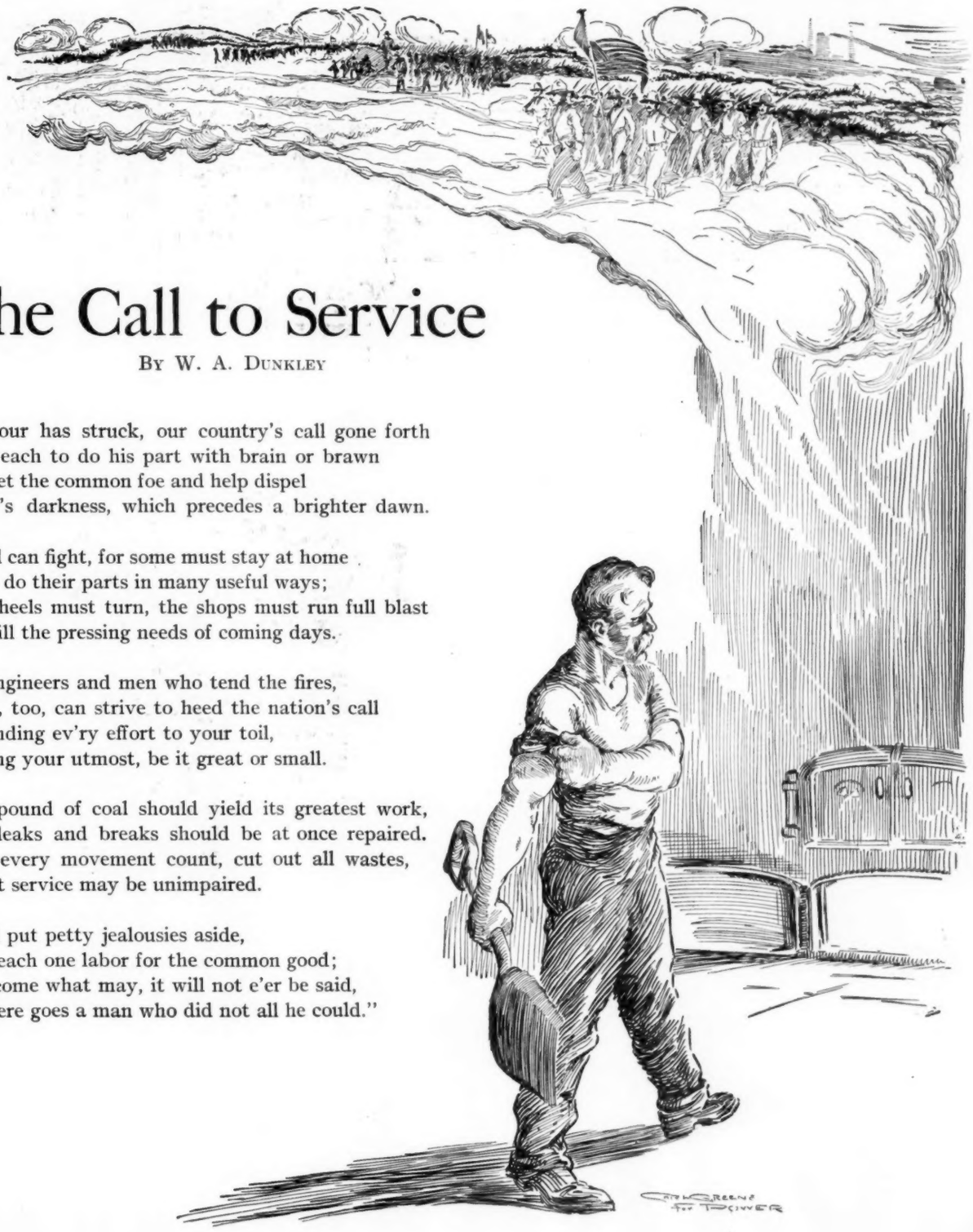
POWER

Vol. 45 NEW YORK, MAY 1, 1917 No. 18



The Call to Service

By W. A. Dunkley

The hour has struck, our country's call gone forth
For each to do his part with brain or brawn
To meet the common foe and help dispel
War's darkness, which precedes a brighter dawn.

Not all can fight, for some must stay at home
And do their parts in many useful ways;
The wheels must turn, the shops must run full blast
To fill the pressing needs of coming days.

You engineers and men who tend the fires,
You, too, can strive to heed the nation's call
By bending ev'ry effort to your toil,
Doing your utmost, be it great or small.

Each pound of coal should yield its greatest work,
All leaks and breaks should be at once repaired.
Make every movement count, cut out all wastes,
That service may be unimpaired.

In zeal put petty jealousies aside,
Let each one labor for the common good;
Then come what may, it will not e'er be said,
"There goes a man who did not all he could."

Weir Meters for the Power Plant

SYNOPSIS—The flow through V-notch meters must be determined by measuring the head. It varies, however, not directly with, but as some function of that head. The article describes the devices for translating head directly into flow, and modifications of the weir to make the flow directly proportional to the head, which constitute the distinguishing features of the weir meters upon the market.

The weir affords a simple method of measuring the volume of flowing water and in several forms has come into use for the measurement of boiler feed and other water supplies in power-plant work.

With the rectangular or other form of notch bounded by more than two sides, the contraction or drawing-in effect bears no fixed relation to the head, making it necessary to introduce a variable correction factor. In 1857 Prof. James Thomson, of Belfast, conducted a series of experiments on weirs having V-shaped notches with an angle of 90 deg., from which he determined that the quantity flowing was 0.305 times the product of the square and the square root of the head, or

$$Q = 0.305H^2\sqrt{H} \text{ or } 0.305H^{\frac{5}{2}}$$

where

Q = The quantity of water flowing in cubic feet per minute;

H = The head measured above the point of the notch in inches.

With such a notch weir the cross-section of the stream retains the triangular form, so that the ratio of depth to

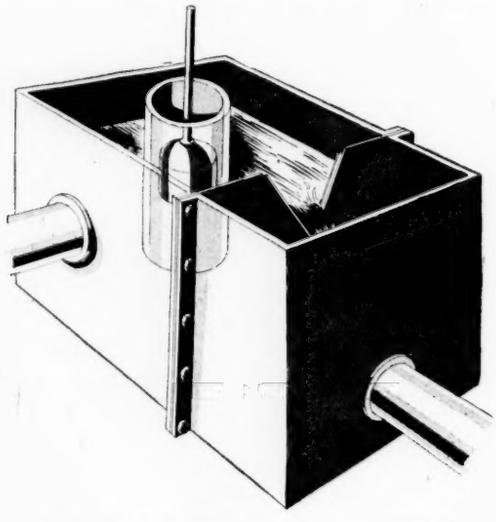


FIG. 1. V-NOTCH WEIR AND FLOAT

width is unchanged, the length of the two wetted surfaces is always the same proportion of the head, and the contraction remains substantially constant. The constant, as 0.305 in the formula, does not vary appreciably through wide variations of flow, and it becomes a simple matter to compute the amount of water passing with a given head. In 1907 Prof. James Barr, of the Glasgow University, extended the earlier experiments of Professor Thomson and found that the flow of water could be measured by the V-notch weir with an error of less than one-third of one per cent.

In order to adapt such a weir for use in a power plant, it must be provided with a device for measuring the head,

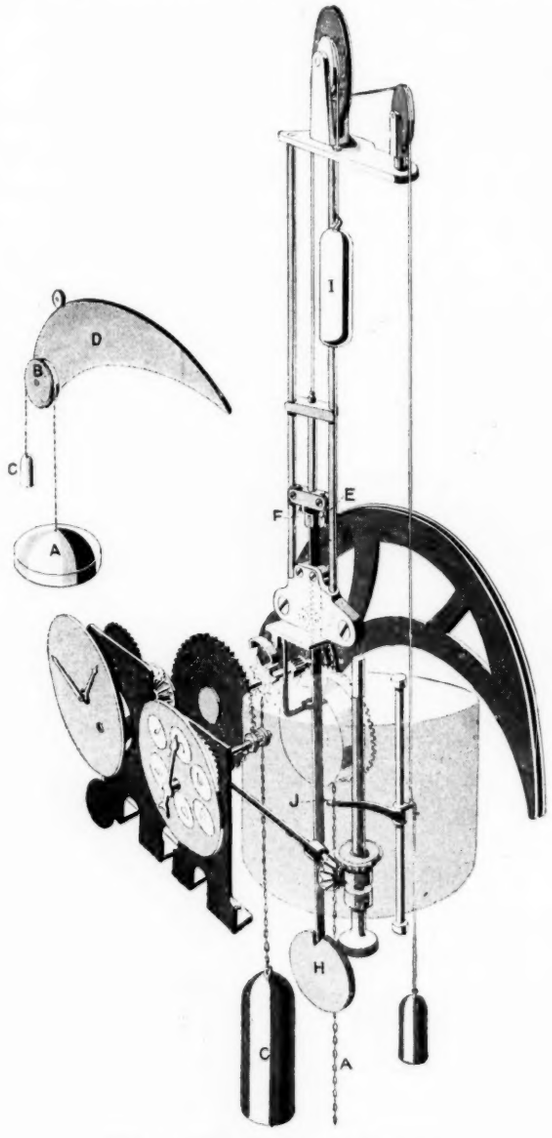


FIG. 2. THE GARDNER METER

translating that measurement into that of the quantity flowing, and indicating, integrating and recording the varying rates of flow and the amounts passed. The usual arrangement is substantially that shown in Fig. 1, the float being in a compartment shielded from disturbance from the flowing of the water, but in free communication with the rest of the tank, so that the level of the still water in it will be the same as that over the weir.

When the amount of water flowing through the notch is small, the head increases rapidly with a slight increase in the rate of flow, but as the notch becomes wider, a given increase in the head or depth of the stream will pass more than a proportionately greater amount of water. Equal rises of the float in Fig. 1 will not, therefore, indicate equal increases in the amount of water flowing, and

it becomes necessary, if, as is desirable, the gage or chart is to be uniformly graduated, to place between the float and the pen some sort of a mechanism which will make the float give to the pen or pointer equal movements for equal variations in the rate of flow rather than for equal changes in the position of the float or in the head, and the essential differences between the various notch meters upon the market consist in the means adopted to effect this purpose.

The Gardner Meter

The time of vibration of a pendulum varies as the square root of its length. If the rise and fall of the float can be made to vary the length of a pendulum so that its vibration should vary as the $\frac{5}{2}$ power of the float's movement, a mechanism actuated through an escapement controlled by the pendulum would indicate or record in uniform divisions the rate of flow. This principle was used in the recorder designed by James A. Gardner and built by Glennock Kennedy, Ltd., of Kilmarnock, Scotland. A chain from the float *A*, Fig. 2, passes over the sprocket *B*, as shown in the detached detail, and is counterbalanced by the weight *C*. On the

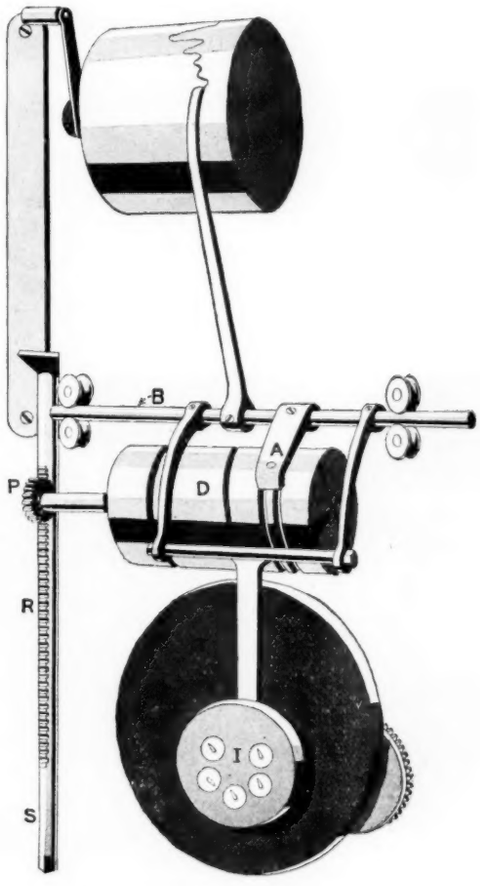


FIG. 3. THE LEA RECORDER

same shaft is a cam *D* upon which rides the roller *E* mounted in the carriage *F*, to the lower extremity of which is attached the upper end of the steel ribbon *G* carrying the pendulum bob *H*. The weight of the carriage and pendulum is balanced by the weight *I*. As the float rises the cam *D* is turned upward, shortening the pendulum and making the clock, the escapement of which it controls, run more rapidly. The variable clock is connected to one member of an epicyclic train of gearing the second member of which is connected to a clock which runs at a constant speed and the third to the recording train; and the gearing is so proportioned and arranged that at a relative speed of the variable clock equivalent to the position of the float when no liquid is passing,

FIG. 4. THE COCHRANE RECORDER

no movement of the recording gear takes place, but movement thereof begins and increases in rapidity as the float rises, the pendulum shortens and the speed of the variable clock increases. A pen *J* records the rate of flow.

The Lea Recorder

A simple method devised by James E. Lea, of Manchester, in 1906 and used in the Lea meter manufactured in this country by the Yarnall-Waring Co., of Philadelphia, uses a cylindrical cam to reduce the unequal movements of the float for the same variation in the rate of flow at different points in the scale to uniformity. The mechanism is shown in Fig. 3. The float rod *S* rotates, by means of the rack *R* and pinion *P* the cylinder *D*. This has cut in it a groove, the pitch of which varies so as to move the pin *A* which rests in it, and with it the slide bar *B* and its connected mechanism, to the left an amount proportional to the change of flow. When the water level is at the point of the notch and there is no flow, the pin is at the zero point on the cylinder, the pen on the zero line of the chart and the integrating mechanism *I* at the center of the disk *T*, which disk is driven at a uniform rate by clockwork. As the water level rises and the

head and rate of flow increase, the cylindrical cam is rotated, carrying the carriage to the left, little at first for a given rise of the float, because at the bottom of the notch the increase in quantity flowing is little for a given increment of head, but more as the head becomes larger,

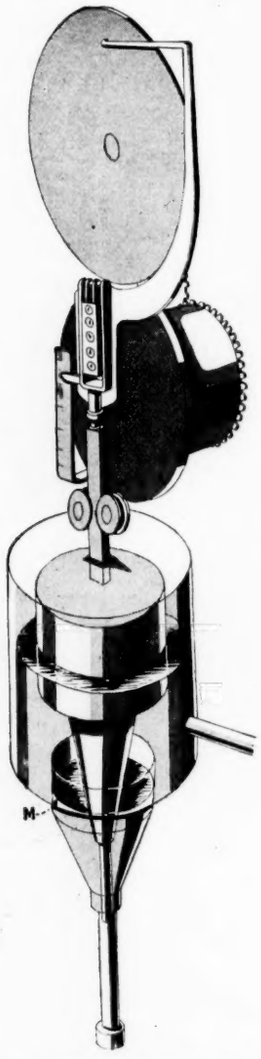


FIG. 5. THE SIMPLEX RECORDER

and always in proportion to the $\frac{5}{2}$ power of the head. The head in inches may be read upon the scale at the left. The rate of flow is recorded upon the time chart at the top, the position of the pen upon the chart being an index of the rate of flow at any moment. This rate is also shown upon a large scale by the graduation of lb. per hour engraved upon the cam drum, and the total amount passed is indicated upon the counter *I*, the movement of which is proportional to the distance of its actuating wheel from the center of the rotating disk behind it.

The Cochrane Meter

A modification of this construction, used by the Harrison Safety Boiler Works, of Philadelphia, in their Cochrane meter, replaces the cylindrical cam by a spiral cam cut in a disk, as shown in Fig. 4. The float is attached to the cord *S*, which winds about a drum on the shaft *B*. A micrometer screw permits the adjustment of the zero point. The float is balanced by the weight *W*, which is suspended by a cord wound about another drum upon the same shaft, but in the opposite direction. When the float rises, the pull of the weight rotates the cam disk clockwise, carrying the carriage *D* to the right an amount proportional to the increase in flow occasioned by the increment of head. The carriage carries at its right-hand end the pen for the recording chart and at the left the

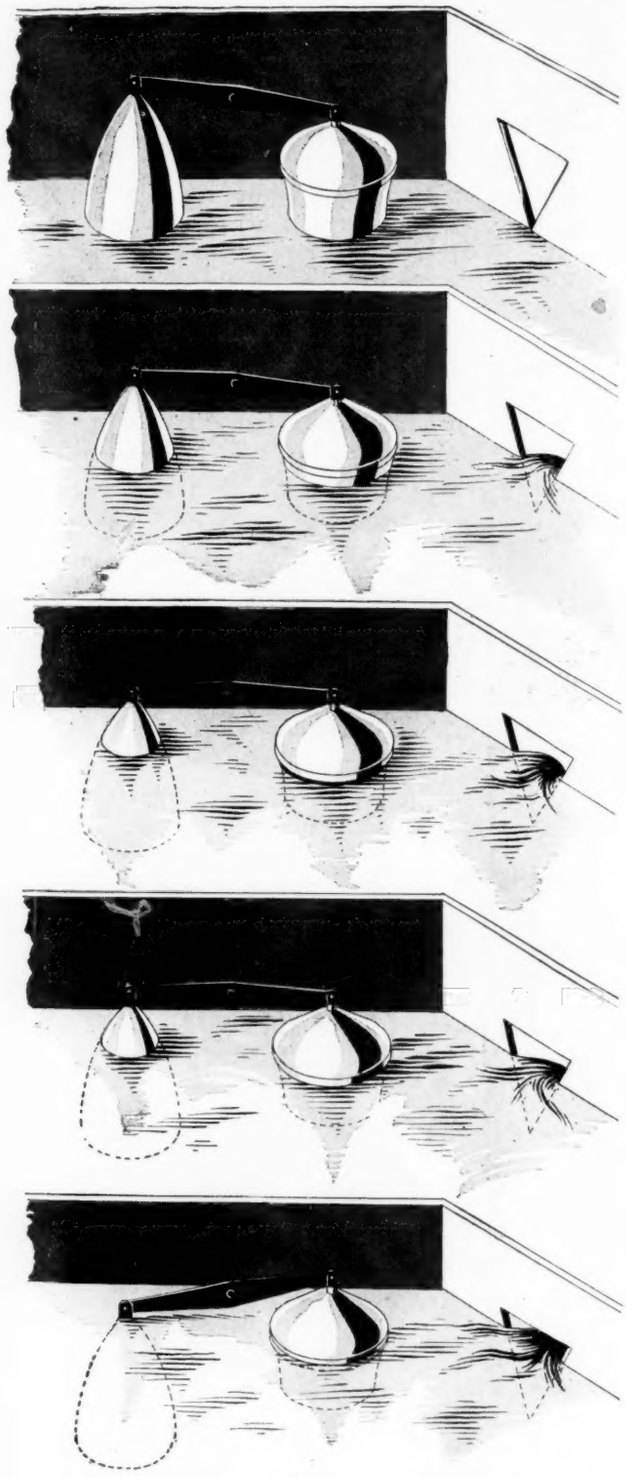


FIG. 6. FLOATS OF THE BAILEY METER

counter for recording the aggregate flow. One of the reasons given for the use of the grooved disk is that on account of the increased radius of the curve at the greater rates of flow, the change in curvature is less abrupt, and there is therefore less thrust in directions other than that in which the carriage is designed to move.

The Simplex Meter

If the weight of the float could be successively changed in the right proportion, it could be made to move through equal distances for equal changes in the rate of flow. This is in effect what is done in the Simplex meter, Fig. 5, invented by J. W. Ledoux and built by the Simplex Valve and Meter Co., of Philadelphia. In the bottom of the float chamber is a volume of mercury M in which a secondary float is partly submerged. When the water level falls, and the float with it, the secondary float is forced farther into the mercury, and the effective weight of the system of floats decreased by an amount equivalent to that of the volume of mercury displaced. The movement of the float, therefore, will not coincide with that of the water level, but may, by varying the contour of the secondary float, be made to vary as the $\frac{5}{2}$ power of the head and thus to be directly proportional to the flow. The movement of the float can in this case be communicated directly to the indicating, recording and integrating mechanism, as Fig. 5 shows.

The Bailey Meter

An equivalent effect may be produced by opposing two floats to each other, both in water. In Fig. 6 the two displacement bodies (for they are really weighted and not

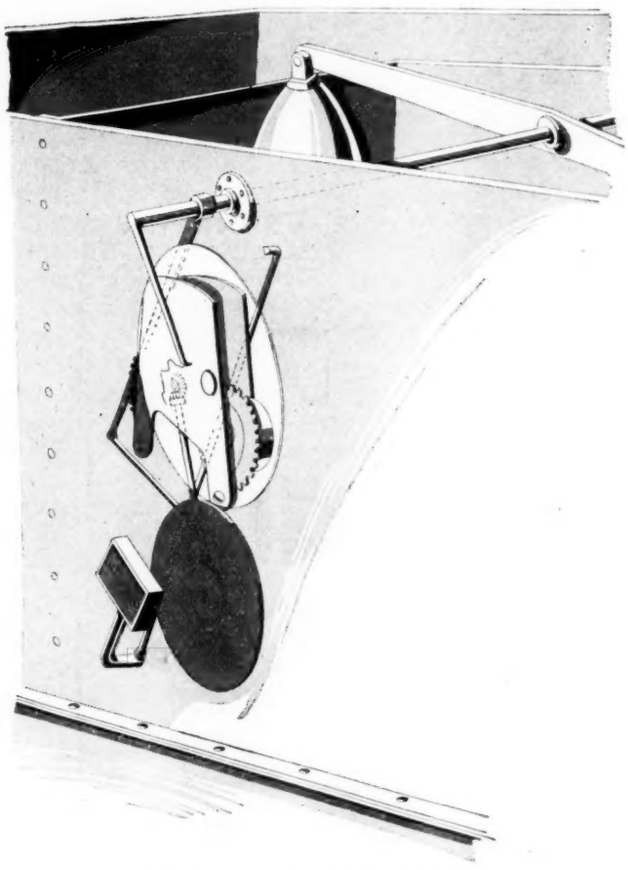


FIG. 7. THE BAILEY METER

floats) are so suspended that their bottoms, which are of the same area, just rest upon the surface of the water when the level is at the zero point, or the point of the notch. The beam upon which they are suspended is free to turn about the center C. The bodies will balance only when they displace equal volumes of water, but the cross-section of one increases upward, while that of the other diminishes. They must therefore be submerged to different depths in order to displace equal volumes and assume a position of equilibrium. The difference in the heights of the two bodies, and thus the angular move-

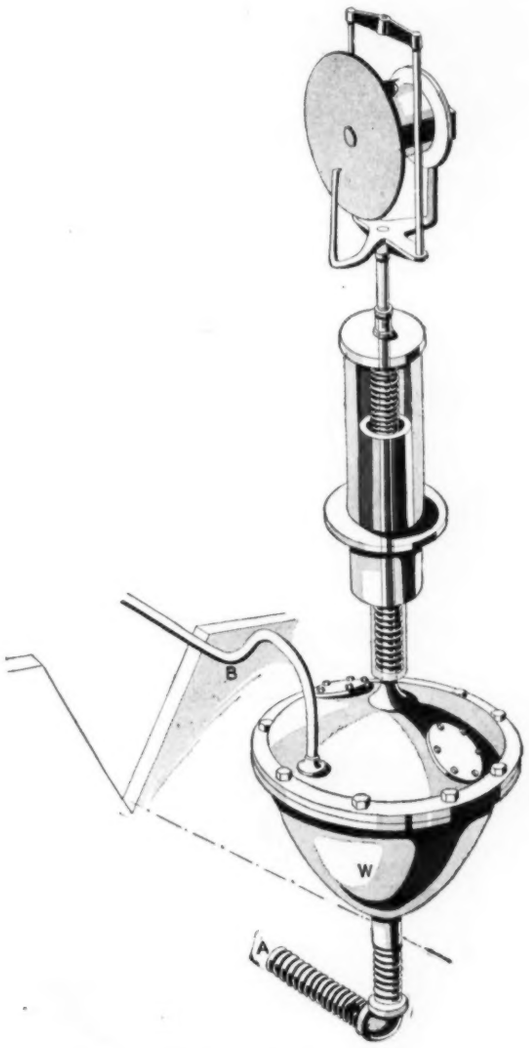


FIG. 8. THE HOPPES RECORDER

ment of the shaft, may be made any desired amount for a given rise in the water level by varying the contour of the two bodies accordingly; and if they are properly shaped, the angular movement of the shaft may be made directly proportional to the $\frac{5}{2}$ power of the head, and thus directly proportional to the flow. Fig. 6 shows the floats in various positions, in each of which each displaces the same amount of water, and Fig. 7 shows how the Bailey Meter Co., of Boston, applies the principle to its meters of the V-notch type.

The Hoppes Weighing Recorder

The Hoppes Manufacturing Co., Springfield, Ohio, uses a recorder in which a vessel W, Fig. 8, is suspended upon a spring scale, its interior being connected to the tank below the level of the V-notch, and to the atmosphere by the flexible connections A and B. When the water is at the zero level of the notch, the vessel is empty and the index of the scale stands at zero. As the level rises and the water begins to flow through the notch, it rises also

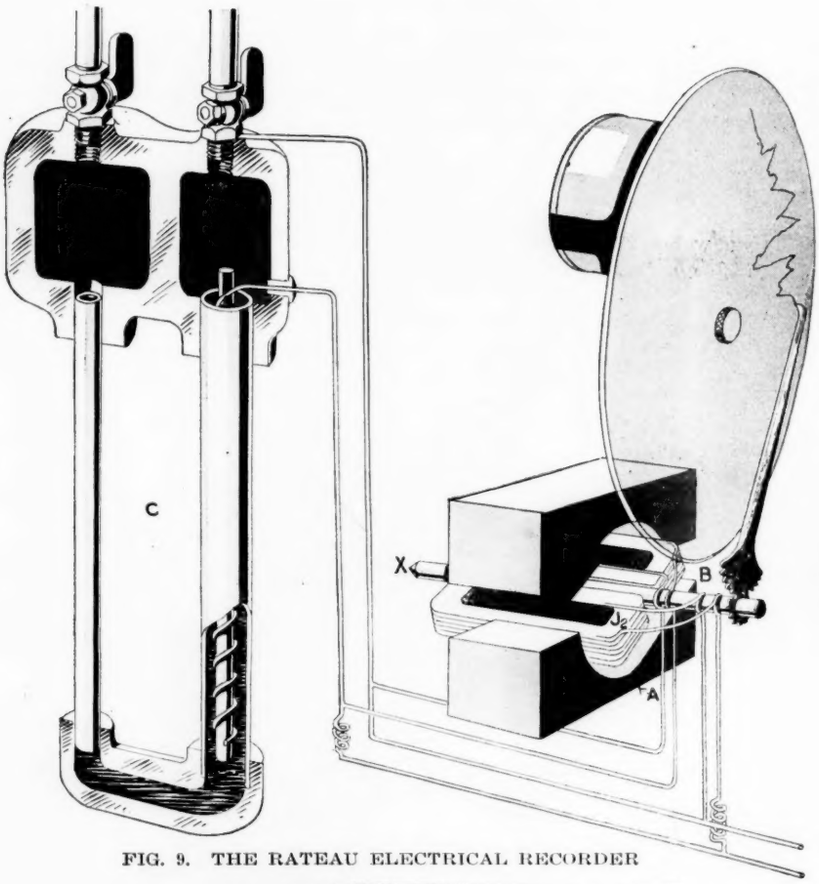


FIG. 9. THE RATEAU ELECTRICAL RECORDER

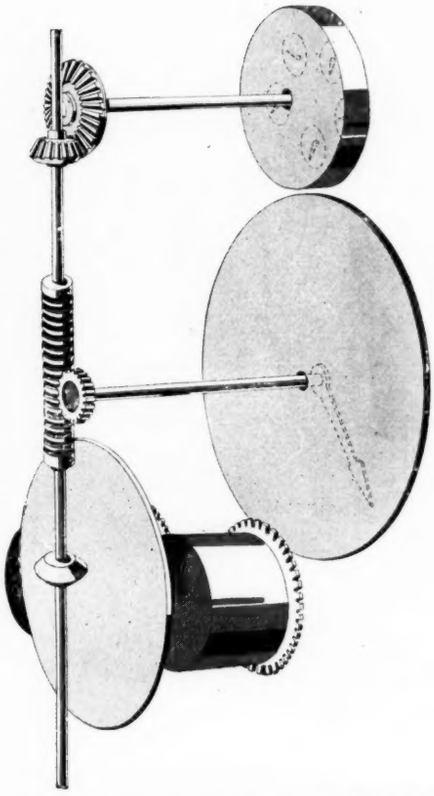


FIG. 13. THE KENNICOTT RECORDER

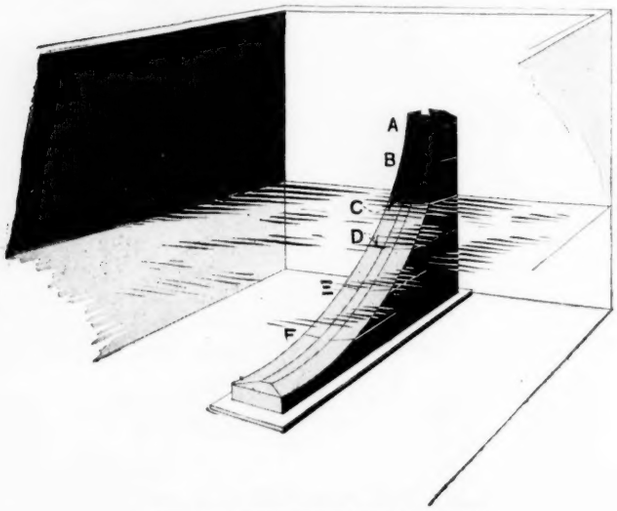


FIG. 12. THE CYCLOIDAL WEIR

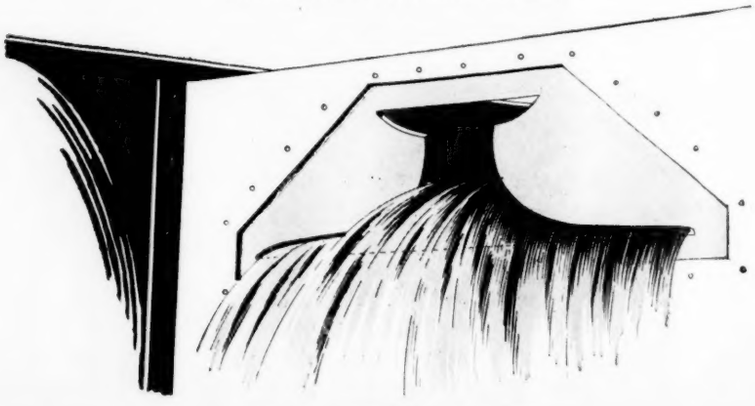


FIG. 10. THE YORKE WEIR

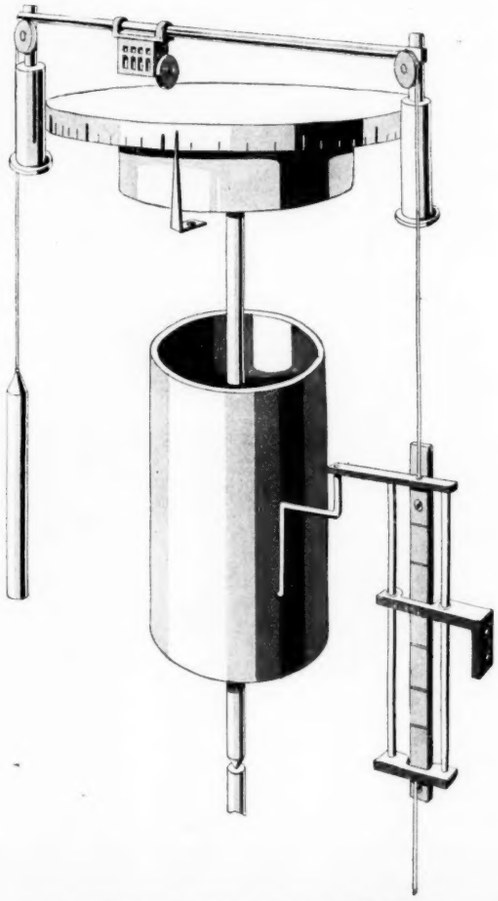


FIG. 11. THE PRECISION RECORDER

in the vessel W, adding to its weight and pulling down on the scale. The increase in weight is greater for a given increment of head, as the head gets greater on account of the increasing cross-section of the vessel, the contour of which is such as to make the weight of water contained vary in proportion to the flow. The connection of the rod to the indicating, recording and integrating mechanism can be made without the necessity of cams or other translating devices.

The Rateau Electric Recorder

In a paper that was presented to the Second Congrés de la Houille Blanche, at Lyons, in 1914, the inventor of the Rateau turbine described a recording mechanism which, although shown in connection with a venturi meter, could perhaps be applied to recording the flow through a V-notch. The principle is shown in Fig. 9, where the head is measured by the difference in the level in the two legs of the U-tube C. The liquid in the U-tube is a conductor, preferably mercury, and in that leg of the tube in which the lower level occurs is placed a conductor, as a wire, so arranged that as its submergence in the mercury varies, its resistance will vary in the desired proportion. This may be done by varying the section of the wire or by winding it in the right kind of a curve. The recording apparatus consists of two coils J_1 and J_2 pivoted upon the axis X, which axis is suspended in a magnetic field, one of the poles of which is cut away in such a way that the distance between the coil J_2 and the pole piece increases with the rotation of the coil. One of these coils, J_2, is connected, as shown, direct to the circuit supplying current to the apparatus, the other, J_1, to the same circuit through the varying resistance. The torque with which the coils turn about the axis X is determined by the difference and by the varying intensity of the field, as the coil J_2 passes from A toward B. The instrument is thus unaffected by any variation in the current that supplies it, other than that occasioned by the varying height of the mercury in the U-tube, and may be supplied by any kind of a current, alternating as well as continuous. The apparatus may also be located at any convenient point and at any reasonable distance from the meter.

The Yorke Weir

The quantity flowing through a weir of any shape is indicated by the formula,

$$Q = CA\sqrt{H}$$

where

C = A constant;

A = The area through which the water is flowing;

H = The height of that area, or the head.

By so designing the shape of the opening that the area varies as the square root of its height, and substituting this value for A in the formula, the formula becomes

$$Q = C\sqrt{H}\ \sqrt{H}, \text{ or } Q = CH$$

that is, the quantity varies directly as the head.

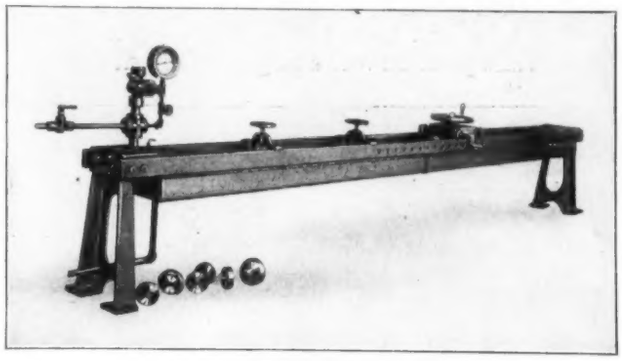
Wilfred Yorke, an Englishman, designed a weir upon this principle, the shape of which is indicated in Fig. 10. The contour of the weir is modified by calibration so as to include the varying contracting effect; in other words, the shape is made such that the quantity flowing, with all the determining factors taken into account, will be proportional to the head. This weir is used in the Precision meter sold in this country by the Precision Instrument Co., of Detroit. Here also the indicating, recording and integrating mechanisms are operated in an obvious manner directly from the float, as shown in Fig. 11.

Another type of weir embodying the same principle and made by the Kennicott Co., Chicago Heights, is shown in Fig. 12. It will be seen that for equal divisions, A, B, C, D, etc., of the head, the area added for the passage of the water to the interior of the weir grows progressively smaller as the head increases. It was found that the curve of a weir so fashioned was that of a right cycloid, and the actual curve obtained by calibration conforms very closely to that curve. The simple apparatus employed for indicating and recording the flow is shown in Fig. 13.

Boiler-Tube Testing Machine

The photograph shows a testing machine for subjecting boiler and other tubing to internal hydrostatic pressure, to be used either with a hand- or power-driven pump. It consists of a frame with two rectangular tie-bars, at one end of which is a stationary abutment and at the other end a moving abutment in the shape of a carriage mounted on rollers, which can be adjusted to the length of the tubes to be tested and then secured to the side frames by pins. A high-pressure hydraulic pump is provided to subject the tubes to a predetermined internal hydraulic pressure.

The tube to be tested is placed in the machine with one end against the fixed abutment; the moving abutment is then brought to bear against the other end of the tube, pinned to the frame, and the tube is made pressure-tight by turning the handwheel. Two intermediate



BOILER-TUBE TESTING MACHINE

clamps operated by small handwheels prevent the tube from buckling while under pressure. The tube is then filled either from a water main, an overhead tank or by a low-pressure pump. After the tube is filled, a high-pressure hand or power pump is used to raise the pressure to the desired test, as shown on a gage.

There is a pan under the bed of the machine to catch the waste water. This pan will serve also as a reservoir if a pump is used for the initial filling.

The machine illustrated is designed to test boiler tubes up to $4\frac{1}{4}$ in. outside diameter to a pressure of 1200 lb. per sq.in. The minimum opening is 5 ft.; maximum opening, 15 ft. The weight of the machine is 2000 lb. Other sizes to meet special requirements can be built, using the same general design. It is manufactured by the Watson Stillman Co., of New York.

Mechanically Operated Electric Elevator Controller

By J. Gintz, Jr.

SYNOPSIS—The functions of the various parts and the circuits of a mechanically operated electric elevator controller are explained.

There are two types of electric-elevator controllers—mechanical and magnetic. The mechanical controller is operated by a cable, either by pulling it directly by hand or through the medium of a handwheel or lever in the car. The hand-rope or cable on the type of Otis Elevator Co. machine described hereinafter, attaches to a sheave which operates a series of cams that close contactors to complete the various circuits and also control the direction of the machine. The mechanical control is generally a one-speed device; that is, it can be run only at full speed, no slow-down being provided, consequently is only applicable to slow-speed machines.

The motor is of the compound type, with the armature, shunt and series-field leads brought out to separate terminals marked *E* and *I*, *D* and *K*, and *F*, *G* and *H*, respectively, as shown in Fig. 3. The two series-field coils are connected in series at terminal *G*. When the motor is running full speed, it is a shunt machine, the series-field coil being cut out, through the accelerating magnet, as this will allow better speed regulation under various loads.

The controller, Fig. 2, consists of a main line or potential switch *P*, which is open when the machine is at rest and is closed by a magnet coil through contactors operated by a cam, located at *A*, Fig. 1. The potential switch is also provided with a magnetic blowout coil which

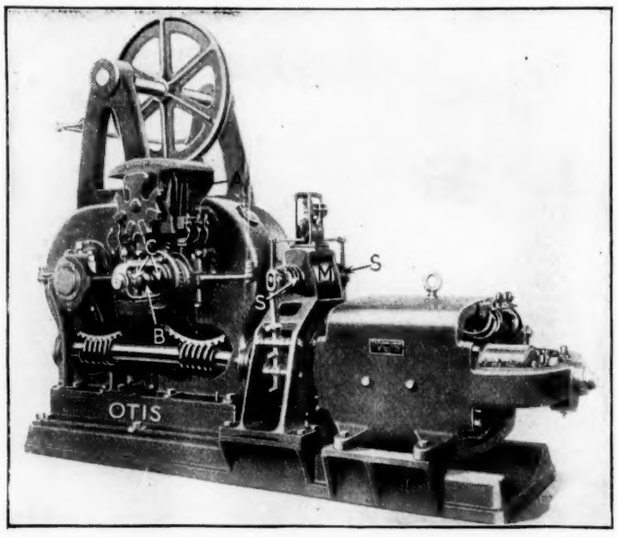


FIG. 1. ELECTRIC-ELEVATOR MACHINE

prevents the arc from being carried between the contacts when the switch is opened. The accelerating magnet *F* is a coil of fine wire fitted over an oval-shaped core on which are arranged four contact arms, two of which (1 and 2) cut out sections of the starting resistance and the other two (*G* and *H*), cut out the series-field coils. These arms are adjusted so that No. 1 is set nearest the core and *H* is the farthest away. This will allow one arm after another to be drawn in. The coil is connected across the armature, therefore the voltage will be increased across its terminal as the pressure increases across the armature terminal, consequently producing a stronger magnetic effect, which will draw in the contact

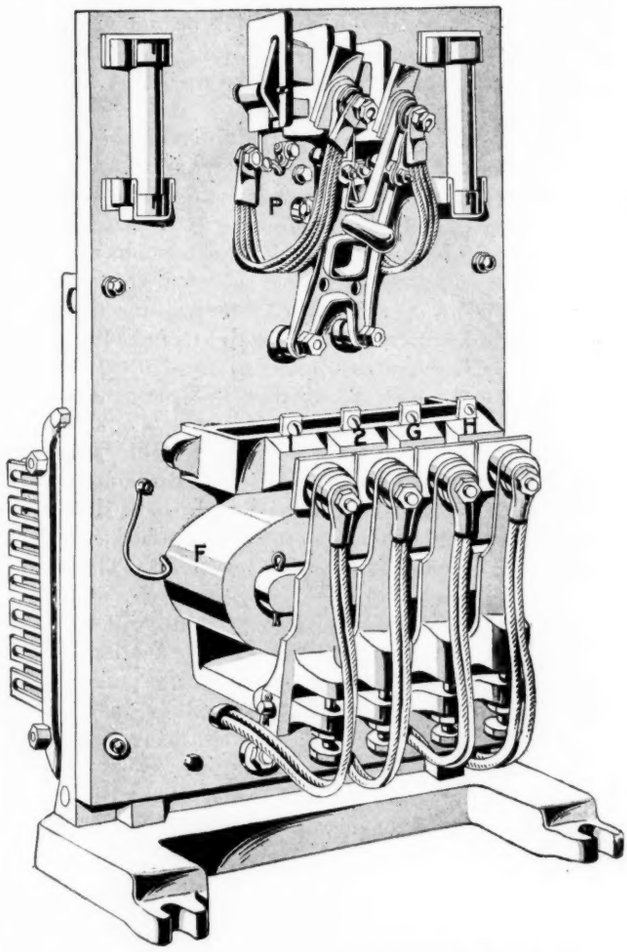


FIG. 2. ELEVATOR-CONTROLLER ACCELERATING MAGNET AND POTENTIAL SWITCH

arms one by one, depending upon the distance they are located away from the coil.

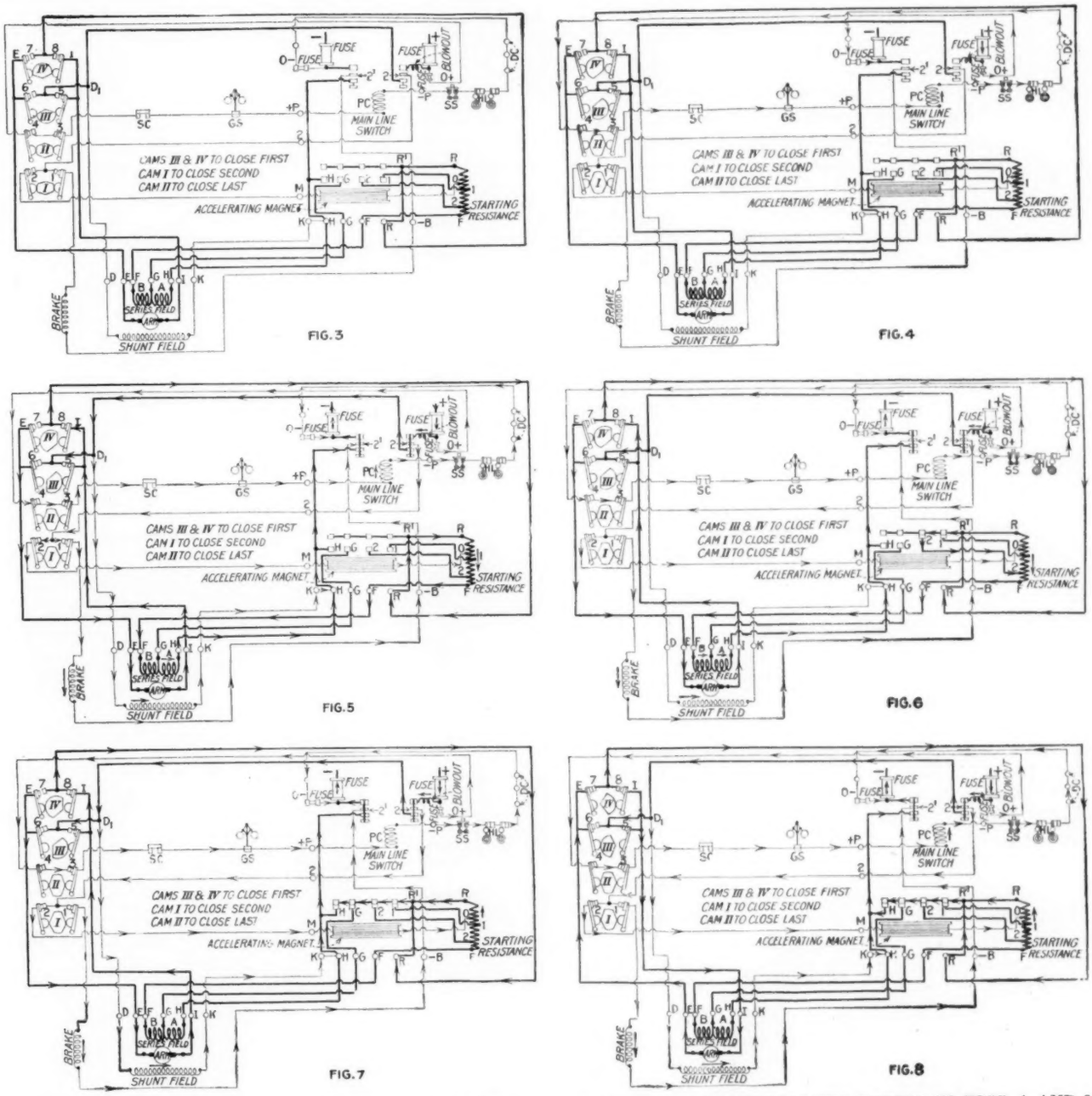
The cams that operate the contact arms are placed at the end of the drum shaft, as shown at *A*, in Fig. 1. The contacts on cams III and IV, Fig. 3, close first and control the direction of the motor. These contactors operate diagonally; that is, contact 6 on cam III and contact 8 on cam IV close at the same time. Assume that these two contactors control the up-motion of the car, then contacts 5 and 7 will control the down-motion. Both the contactors on cam I close second; contactor 1 completes the brake-coil circuit and 2 the accelerating-magnet-coil circuit. Both contactors on cam II close after those on I; these contactors close the main-line or potential switch circuit by completing the circuit through the magnet coil and safety-device circuit, which includes the safety switch in the car, the slack-cable switch, the

governor switch, the upper- and lower-limit switches and the door contactors. If any of these devices are open, the potential switch cannot close, therefore the motor will not start. When stopping the machine, the contact on cam II opens first, causing the main-line or potential switch to open, and the brake is then applied, which will bring the machine to a full stop. The brake shoes are raised by an electromagnet *M*, Fig. 1, and are applied by the heavy spiral spring *S*.

When the car reaches the upper or lower end of the hatchway, there are three limit appliances which will stop it, if anything should happen to the operator or go wrong with any part of the machinery or car while it is running.

The first stopping device is the stop balls, which are clamped to the hand-rope at the top and bottom landings. These balls strike a fitting, fastened to the top of the car, through which the hand-rope passes and perform the function of the operator by pulling the operating cable up or down, depending upon the motion of the car. Should this safety device fail, the traveling nut *B*, Fig. 1, on the end of the drum shaft will be caught by one of the fixed nuts *C* and act to bring the machine to rest. The third safety device is the upper- and lower-limit switches in the shaft, which are in series with the magnet coil on the potential switch. By opening the circuit of this magnet coil, the switch will drop out and open the line. These safety stops are located at the upper and lower end of the hatchway, to prevent the car from being jammed into the overhead work or striking the bottom of the pit.

When the operator in the car pulls the hand-rope down to start it on the up-motion, the cams will close the contactors, as shown in Fig. 4; that is, cam IV



FIGS. 3 TO 8. WIRING DIAGRAMS EXPLAINING THE OPERATION OF THE CONTROLLERS SHOWN IN FIGS. 1 AND 2

will close contactor 8, cam III contactor 6, cam II will close contacts 3 and 4, and cam I contacts 1 and 2. As previously explained, contacts 3 and 4 close last and complete the circuit from the positive side of the line, through the slack-cable switch *SC*, the governor switch *GS*, the potential-switch coil *PC*, the safety switch *SS* in the car, the upper- and lower-limit switches *HL* in the hatchway, the door contactors *DC*, and back to the negative side of the line, as indicated by the arrowhead.

Circuits Through the Motor and Controller

With this circuit energized the potential switch closes, as shown in Fig. 5, which completes the motor, brake-coil and accelerating-magnet-coil circuits. The armature circuit is from the positive side of the line, through the blowout coil on the potential switch, through the heavy conductor to contact 6 on cam III, from here to terminal *E* on the armature, through the armature to terminal *I* and back to contactor 8, which is closed, from here to terminal *R* on the control board, and through the starting resistance to terminal *F* on the series-field coils at the motor, through the series-field winding to terminal *H* and back to the negative side of the line, as shown. The shunt field is energized from a tap taken from the wire at cam III, at point D_1, from here to terminal *D* on the motor, through the shunt field to terminal *K* on the control board, which connects with terminal *H*, and back to the negative side of the line, as indicated.

The brake-coil circuit is from contact 2 on the positive side of the potential switch to contact 1 on cam I, through the brake-magnet coil to terminal —*B* on the control board, and to contact 2′ on the negative side of the potential switch.

The accelerating-magnet circuit is completed through contact 2 on cam I, and the flow in the current is from contact 2 on the potential switch to contact 2 on cam I, to terminal *M* on the controller board, then through the accelerating-magnet coil to *O* on the starting resistance, through the starting resistance to terminal *F* on the controller, and the series-field coils to *H*, and back to the negative side of the potential switch, as indicated by the arrowhead.

The Acceleration of the Motor

With the circuits closed, as explained in the foregoing, the motors should start and increase in speed; then, as the voltage across the armature terminals is increased, the magnetic pull of the accelerating-magnet coil will be increased and resistance contact 1 will close. This will short-circuit part of the starting resistance out of the armature circuit and cause the motor to increase its speed, and then contact 2 will close and short-circuit another section of the starting resistance. The path of the current through the controller with resistance-contact arm 1 and 2 closed, will be as shown in Fig. 6. In this case the circuits are practically the same as in Fig. 5, except instead of the armature current flowing through all the starting resistance, it only passes through the section between 2 and *F*, the circuit being from *R* to *R*′ to contact arm 2, on the accelerating magnet and to point 2, on the starting resistance to terminal *F* of the series field, through the series field to terminal *H* and back to the negative side of the line. The motor is now running at very nearly full speed, as a compound machine with a small section of a starting resistance still in the circuit.

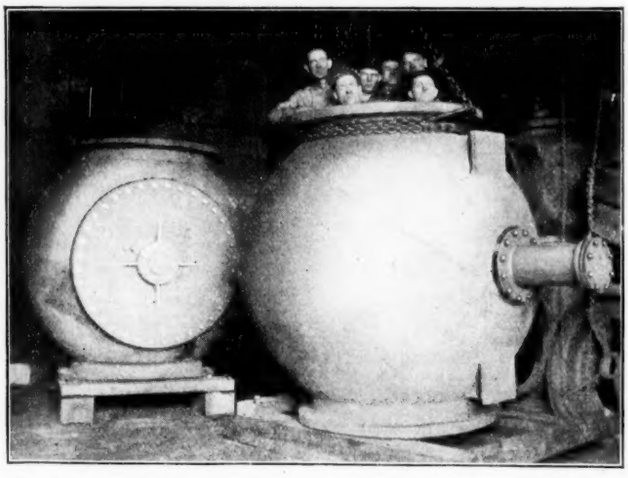
The next contact arm to be drawn in is *G*; this will cut out one of the series-field coils *B* and the remaining portion of the starting resistance, which will further increase the speed of the motor; then contact arm *H* will be drawn in. This cuts out the other series-field coil *A*, and the motor is now running as a shunt machine at full speed.

The direction of the flow of the current is shown in Fig. 7 and is from the positive side of the line to contact 6 on cam III, to terminal *E* of the armature, through the armature to terminal *I*, to contactor 8 on cam IV, from here to terminal *R* on controller board to *R*′, then through contacts 1, 2, *G* and *H*, to the negative side of the line.

To reverse the direction of the motor the cams are thrown to the opposite position, as shown in Fig. 8. It will be seen that contacts 5 and 7 on cams III and IV are closed instead of contacts 6 and 8. By tracing out the circuit, it will be found to be the same as in Fig. 7 except the direction of the current through the armature, which is reversed as indicated by the arrowheads.

Large Exhaust Relief Valves

The illustration shows two horizontal relief valves built by the G. M. Davis Regulator Co. for the American Gas and Electric Co., Beach Bottom, W. Va., for use in connection with its condensing turbines. The valves are



TWO EXHAUST VALVES ABOUT READY TO SHIP

designed to relieve the exhaust to the atmosphere when it reaches a pressure of ¼ lb. above that of the atmosphere, or they may be opened under a partial vacuum by means of the hydraulic operating cylinder provided, and controlled by a three-way cock.

The total weight of the two valves is approximately 23,000 lb., and a general conception of their size may be gained by observing that there are six men within the inlet opening.

Cement to Resist Red Heat and Boiling Water—To four or five parts of clay, thoroughly dried and pulverized add two parts of fine iron filings, one part of peroxide of manganese, one-half of sea salt and one-half of borax. Mingle thoroughly, then reduce to a thick paste with the necessary quantity of water. It must be used immediately. After application it should be exposed to warmth, gradually increasing to a white heat. This cement is very hard and presents complete resistance alike to red heat and to boiling water.

Turbine for Locomotive Drive

By Victor W. Zilen

SYNOPSIS—The author proposes reversible, single-stage, impulse, velocity-compounded, non-condensing turbines for each locomotive driver. The turbines are to be geared. The locomotives should give much more power than the reciprocating type of machine in the limited space available.

In spite of the excellent showing made in raising the drawbar pull of high-speed passenger locomotives, the railway mechanical engineer is still confronted with the problem of developing a higher power in the limited space. Locomotives develop their maximum power when the piston speed is from 700 to 1000 ft. per min. An engine adapted to high speeds must necessarily have correspondingly large diameters for the driving wheels; and as the number of driving wheels is limited by the conditions of the rigid wheelbase and the wheel loads are limited by the strength of the rails, there seem to be but few possibilities of having larger locomotive power plants of the present type.

Attention is therefore being directed to the steam turbine for locomotive drive. With turbines the drivers may be run at much higher speeds, in revolutions per minute, and more drivers may be employed to increase the drawbar pull. The uniform rotative motion of the turbine will eliminate the shocks produced by the reciprocating parts of the present types of engines.

A company established in Milan by several engineers attempted the solution, and a turbine of special design was applied to an old locomotive and extensive experi-

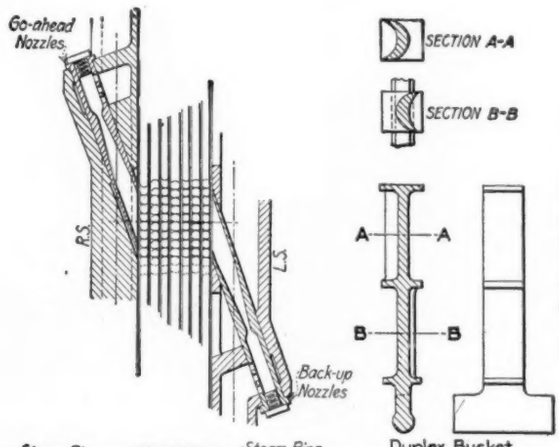


FIG. 1

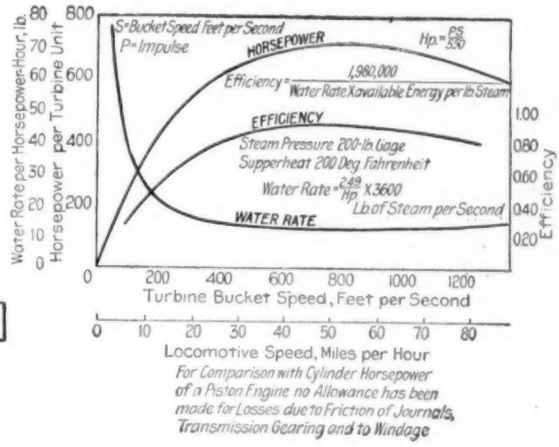

S=Bucket Speed Feet per Second
P=Impulse
HORSEPOWER
Hp.=PS/550
Efficiency=4,980,000 / Water Rate X available Energy per lb Steam
EFFICIENCY
Steam Pressure 200-lb Gage
Supperheat 200 Deg Fahrenheit
Water Rate=249/hp X 3600
Lb of Steam per Second
WATER RATE
Water Rate per Horsepower-Hour, lb.
Horsepower per Turbine Unit
Efficiency
Turbine Bucket Speed, Feet per Second
Locomotive Speed, Miles per Hour
For Comparison with Cylinder Horsepower of a Piston Engine no Allowance has been made for Losses due to Friction of Journals, Transmission Gearing and to Windage

FIG. 3. PERFORMANCE CURVES OF TURBINE LOCOMOTIVE

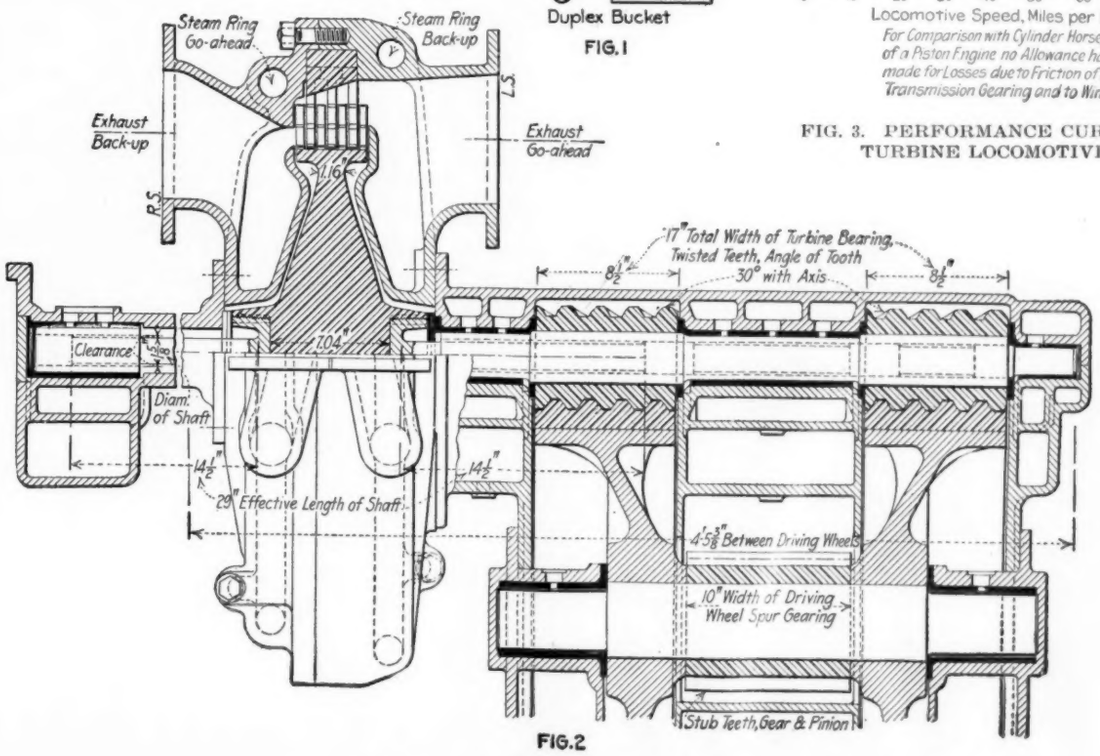


FIG. 2

FIGS. 1 AND 2. SECTIONS OF TURBINE FOR LOCOMOTIVE DRIVE

Fig. 1—Showing the duplex bucket, part of its length being for ahead motion, part for the reverse.
Fig. 2—Section of the turbine, showing pinions and gearing

ments were made. One of the engineers, Mr. Belluzo, has published some of the observations taken during these experiments[1]. Miani Silverti, Comi and Grodona, in Milan, made a practical trial of such a turbine. The locomotive to which the turbine was later applied was built in 1876. The boiler had a heating surface of about 700 sq.ft. and steam pressure about 9 atmospheres. The locomotive was operated by a turbine which gave 100 hp. The steam consumption never exceeded 38 lb. per hp.-hr. for both directions of revolutions. The weight on two axles was 26 tons. A locomotive of double the weight with a turbine of 6 to 10 times the power would give much lower figures, if the boiler pressure were 50 per cent. higher. The locomotive started well under load both on curves and on gradients; the turning moment was a little less than 1229.63 foot-pounds.

Experience dictates that any contrivance intended to supplement some existing device performing similar functions will at first be looked upon with disfavor, especially in railroad circles. With these points in view the writer worked out a preliminary design for a reversible turbine for driving locomotives, which is shown in the illustrations. The turbine is of the impulse type, single-stage, velocity compounded and noncondensing. Two conditions have to be met, namely, the possibility of reversing and economic working at varying speed. Fig. 1 shows the reversing buckets.

When an attempt is made to provide for reversing and to overcome the difficulty in getting rid of the steam when its relative velocity approaches negative value at certain speeds of the rotor, it will be found that there are not many ways by which this can be accomplished, especially when simplicity of construction is one of the requirements.

Arrangement of Buckets for Reversing

The reversibility has been obtained by a special construction of the buckets (see Fig. 1). Two buckets of opposite curvature are made in one piece; when running in one direction the steam passes through the buckets having for one-half their length the shape for running in that direction; the other half is curved for running in the opposite direction, and steam is passed through these latter parts of the buckets from a set of nozzles intended for reversing. The rotor has four sets of these duplex buckets (see Fig. 2). At high speed the steam strikes only the first and second sets of the moving buckets in succession and is guided by blades placed between; the guide blades are stationary and so constructed that whenever the velocity of the steam becomes less than the speed of the moving buckets the steam, if thrown off by centrifugal action radially, can pass out to the exhaust space unrestricted. To facilitate getting rid of the dead steam at certain speeds of the buckets, a third set of the moving buckets has plain ends to allow bypassing of steam radially into the exhaust space. At low speed the steam strikes all the buckets in succession, while at intermediate speeds two and three sets may come into play.

The turbine is for a steam pressure of 215 lb. per sq.in. absolute, and 200 deg. F. superheat.

Fig. 3 gives the horsepower, efficiency and water-rate curves. For comparison with cylinder horsepower of a piston engine, Fig. 3 makes no allowance for losses due to friction of journals, windage and transmission gearing.

[1]International Railway Congress, Bull. 25, 1911, page 265.

[The reader should be cautioned that Fig. 3 is purely theoretical, that it refers to a turbine intended for 215 lb. pressure, 200 deg. superheat, and not to the machine of Miani Silverti, Comi and Grodona. Many will question that a turbine of the type shown in Fig. 2 will give performances indicated in Fig. 3.—Editor.]

Bristol's Automatic Temperature Controllers

Temperature measurement in industrial and manufacturing plants must logically include the measuring and indicating of the temperature with a reading instrument, automatically recording the temperature with

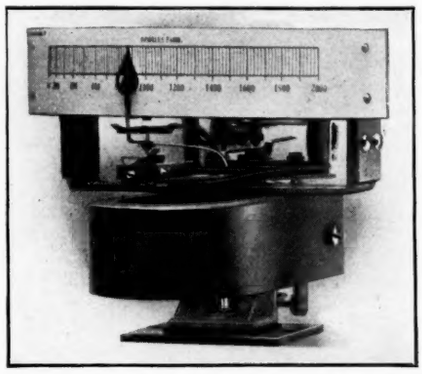


FIG. 1. CONTROLLING ELEMENT

a graphic recording instrument and automatically controlling the temperature, thus eliminating the personal element. To this end the Bristol Co., of Waterbury, Conn., has developed a new line of automatic temperature controllers for gas- and oil-fired and electrically heated

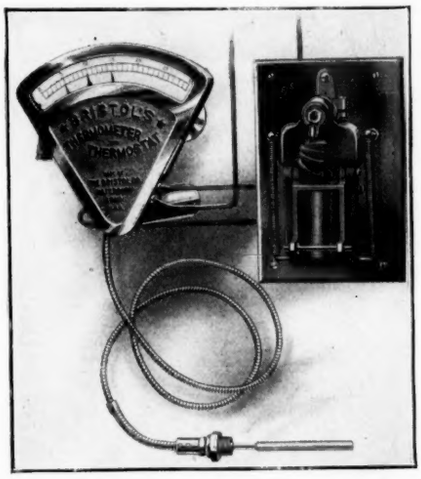


FIG. 2. THERMOMETER THERMOSTAT, SENSITIVE BULB AND RELAY SWITCH

furnaces, the principle being to employ an operating element and a controlling element, the resulting temperature being indicated by a reading instrument.

The regulation of temperature is accomplished by means of an indicating pyrometer equipped with an independent mechanically operated contact for opening and closing an electric control circuit. The required temperature is designated by adjusting the index to that point on the scale of the pyrometer. In Fig. 1 the index is set at 900 deg. F.

The measuring element may be one of a number of different types of electric pyrometers and thermometers, notably the thermo-electric pyrometer with Weston millivoltmeter movement and Bristol separable couples, as well as the vapor-filled type of thermometer. The controlling element is combined with the measuring element

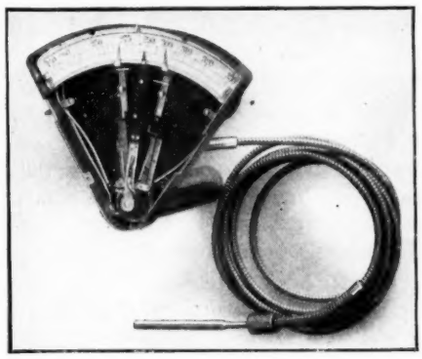


FIG. 3. INTERIOR OF THE THERMOSTAT

and consists primarily of an electrical contact-closing device that operates at predetermined high and low temperatures, electrical circuits being closed or opened by this means and energizing or disconnecting the operating element.

The operating element consists of the device that actually regulates the heat supply in the furnace. In a gas-fired furnace, for example, a pair of electrically operated gas and air valves are used, but in the case of an electric furnace the operating element consists of a special relay switch opening and closing the circuits of the heating element of the furnace.

Fig. 1 is an internal view of the measuring and controlling elements of the thermo-electric type. The indicating arm is insulated from the operating circuits, the contacting device being frictionless. These controllers are made for temperatures up to 3000 deg. F. and with high-resistance movements for use with either base- or precious-metal couples.

In Fig. 2 is shown one of the vapor-type thermometer-thermostats, complete with a sensitive bulb and connected to the special relay switch employed for adapting these instruments to the control of temperatures in electric ovens and furnaces. The interior of the thermostat is shown in Fig. 3. Both the high and the low contacts are shown, but with the automatic electrical controlling valves for both gas and air supply, only one contact is required.

Report on Heat-Insulating Materials*

SYNOPSIS—Gives the results of tests of various heat insulating materials compared with tests of common firebrick.

The first object of the tests described here was to determine the relative thermal insulating value of the materials examined. The materials were obtained in or were cut to the dimensions of standard bricks, so that in this respect the samples were equal. The idea worked on for this comparison is best explained by Fig. 1.

If the brick was subjected to a high temperature source of heat at the end *A*, then if the top, bottom and sides were thoroughly insulated, the heat that entered at *A* would be radiated from the exposed end *B*. Thermometers placed in the brick at distances between *A* and *B* would show a uniform drop in temperature. With the same temperature at *A* a brick made of a good insulating material would give lower readings on the thermometers placed in the brick than would be the case for a poor insulating material—the thermometers being in the same relative positions. The diagram drawn to show this temperature gradient for a good and poor insulating material would be as in Fig. 2.

The difficulty, which was expected, was found to be in insulating thoroughly the top, bottom and sides of the bricks. Naturally, it is difficult to insulate a material that is itself a good insulator. It was thought that if the top, bottom and side insulation was made practically the same for each material, the comparisons would be reliable, as shown by the temperature gradients. For this reason it was expected that the diagram, as given, would be modified as shown by the dotted lines in Fig. 2.

Experiment showed that this was the case, and it was decided to run a series of tests under these conditions.

To obtain the high-temperature source of heat and to give each sample exposure to the same temperature required some experimenting to find the best form of furnace; the one shown in Fig. 3 was adopted.

The furnace was built of Osceola firebrick; the base of slabs 4 in. by 20 in. by 12 in.; the housing for the gas torch had sides 1¼ in. thick; the roof was of standard bricks.

All samples of the materials were carefully bedded into position and equally spaced and insulated from one another. A chase was cut to enable a thermocouple to be inserted so that the temperature of the source of heat could be measured. The thermometer holes were cut in the bricks, and after placing the thermometers in position, the holes were packed with powder of the same material as the brick.

The method of testing was to read all thermometers, then place the gasoline torch in position and take readings every 15 or 30 min., the idea being to keep the high-temperature source of heat as steady as possible. The gasoline torch did not possess much flexibility and was difficult to regulate satisfactorily.

Curves were then plotted showing the rate of increase of the temperatures at the different thermometer positions, as indicated in Fig. 4.

At the time *T* when equilibrium was established a cross-plot was made, giving the temperature gradient, which was considered to be a measure of the insulating value of the material, as explained previously.

The curves for each material, while giving all the information, are not easy to grasp, so interpolated curves have been made which give all materials tested on the same sheet under the same conditions. These curves are shown in Fig. 5. On examination of Fig. 5 there does not appear to be so much difference between the fire and the insulating bricks compared by this method of temperature gradient, and it might be said that, roughly,

*From tests by Sargent and Lundy, consulting engineers, Chicago.

6 in. of firebrick is equal to 4 in. of insulating brick, which on general principles is not reasonable. As a matter of fact, such a deduction cannot be made, for it must be remembered that the true law of radiation from a body is proportional to the difference of the 4th powers of the temperatures of the radiating surface and the medium into which the radiation takes place. That is,

$$Radiation = K(T_1T^4 - T_2T^4) \qquad (1)$$

where K is a constant, T_1 the absolute temperature of the radiating surface, and T_2 the absolute temperature of medium into which radiation takes place. Consequently the relative values are much greater than shown.

It must be pointed out that, though every precaution was taken to insure comparative conditions, it follows

The method adopted was to build a furnace of the various materials, cut to the dimensions of standard bricks and carefully laid up with small joints, as shown in Fig. 6. These furnaces were heated by means of an electrical heater made of arc-lamp resistance coils and arranged to evenly distribute the heat over the inside. The electrical energy can be measured with great accuracy and could be exactly adjusted. The electrical input to the heater was converted into B.t.u. by multiplying the watt-hours consumed by 3.412, as it was thought advisable to use the B.t.u. as the unit of heat and not to express it in electrical units.

If the electrical input is constant, then the temperature will rise in the furnace until the temperature differ-

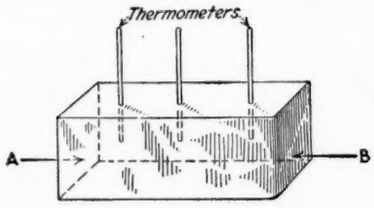


FIG. 1

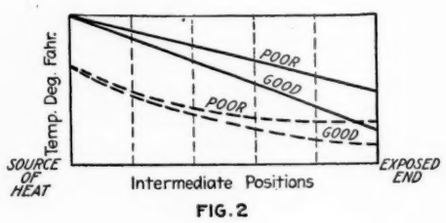


FIG. 2

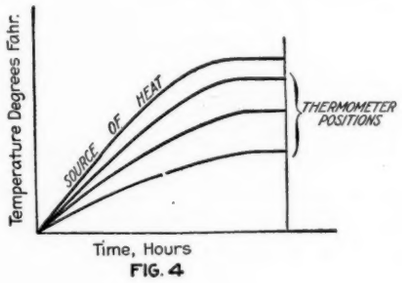


FIG. 4

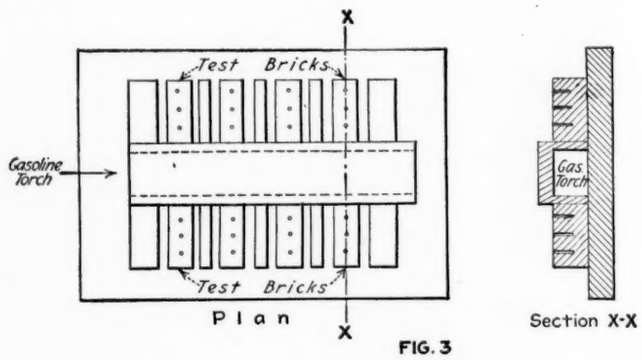


FIG. 3

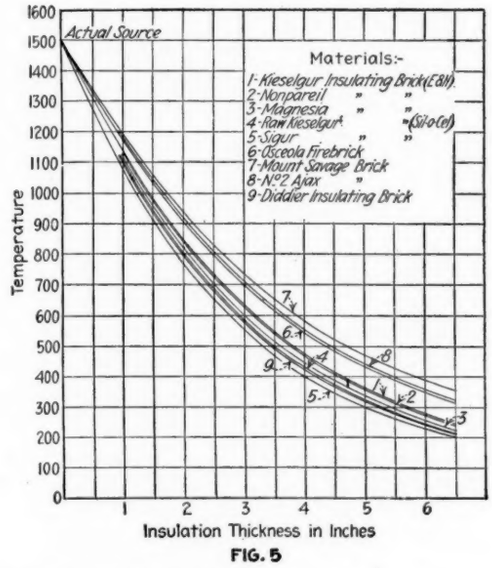


FIG. 5

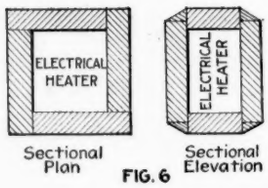


FIG. 6

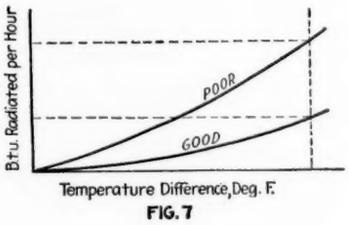


FIG. 7

FIGS. 1 TO 7. THE TESTING OF HEAT-INSULATING MATERIALS

Fig. 1—Arrangement of thermometers in brick. Fig. 2—Temperature gradient for good and poor materials. Fig. 3—Form of furnace used for heating brick. Fig. 4—Showing rate of temperature increase for thermometer positions. Fig. 5—Interpolated curves, showing behavior of different materials. Fig. 6—Materials formed into furnaces. Fig. 7—Showing shapes of curves giving relation of radiation to temperature difference

from equation (1) that a very small difference, in various ways, such as the high-temperature source, thickness of insulation between samples, etc., might place a material in the wrong position on the sheet, particularly as the curves are so close together, and it is well known that magnesia is equal in insulating value to many times its thickness in ordinary firebrick, so long as disintegration does not take place.

It was therefore considered that some other method should be found to obtain a more absolute comparison and that it should be on the basis of measuring the actual quantity of heat passing through the material under test. This would be a true value of the heat-insulating value of the materials.

ence between the inside and outside is sufficient to cause the heat generated to be dissipated at an equal rate; then equilibrium is established. On establishing equilibrium, readings were taken of the electrical energy and the temperature of the inside and the outside of the furnace. By varying the electrical energy a curve can be drawn between the temperature difference of the inside and the outside of the furnace, and the B.t.u. radiated per hour. Such curves are of the shape of those which are shown in Fig. 7.

In this diagram it will be seen that at a given temperature difference between the inside and the outside of the furnace the good material radiates considerably less heat than the poor one.

Fig. 8 shows these curves for the materials tested, which were run in duplicate as a check. By this method is easily seen the great advantage, from a thermal point of view, the insulating materials have over the ordinary firebrick.

From the shape of these curves it is seen that the materials have not such a good insulating value at high temperatures as at low ones; for example, take Osceola firebrick, as it is naturally more marked in this case:

Temperature Difference, Deg. F.	B.t.u. Radiated per Hour
500	1,000
1,000	2,500
1,500	5,000
2,000	11,500

To express this variation in insulating value with the temperature, it was thought that a similar relation to Ohm's law might be found. This was proved to be so. The unit taken has been called the "thermal Ohm" and is expressed by dividing the temperature difference by the B.t.u. radiated per hour.

These values for the materials have been calculated and are given in Figs. 9 and 10. These show practically straight lines (except for magnesia and a combination of sigur and magnesia, marked Si.-Mag.) With this latter material the "thermal resistance" decreases directly as the temperature difference.

The reason magnesia falls off so rapidly at the high temperatures is because a chemical change takes place and it becomes disintegrated. Even when subjected to low temperatures, it is only a matter of time before disintegration takes place, as is well known from the behavior of magnesia coverings for steam pipes.

The "Si.-Mag." furnace was made of half thickness of sigur and half of magnesia; it was considered that the sigur might protect the magnesia sufficiently so that its extra insulating qualities might be utilized; but this combination has the same characteristics as the plain magnesia, although of course not so pronounced.

To use the figures thus obtained, to find the equivalent thickness of material required to give equal insulation—that is to say, equal thermal resistance, in each case—it is necessary to demonstrate experimentally the laws of thermal resistance. To do this, furnaces of half and twice the thickness of the original furnace were built and tested. The results proved that the thermal insulation is directly proportional to the thickness.

The material of highest thermal resistance is the raw Kieselguhr product (trade name, Sil-o-cel); the other materials are therefore expressed in terms of this material. These figures are shown in Fig. 11.

At 2000 deg. F. the relative values are as follows:

1 thickness of Sil-o-cel equals	6.5 thicknesses of Osceola firebrick
	1.85 thicknesses of Diddier insulating brick
	1.65 thicknesses of Si-Mag. insulating brick
	1.35 thicknesses of Sigur insulating brick
	1.20 thicknesses of Nonpareil insulating brick

From the known dimensions of the furnaces the B.t.u.'s radiated per hour per square foot of surface for various temperature differences are figured. These results are

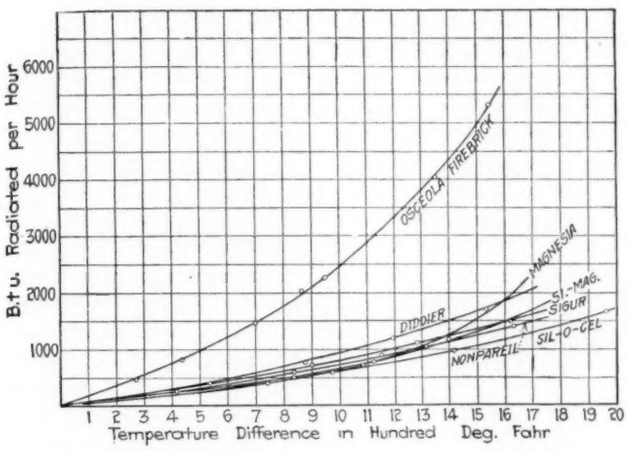


FIG. 8. BEHAVIOR OF COMMON FIREBRICK COMPARED WITH THAT OF INSULATING MATERIALS

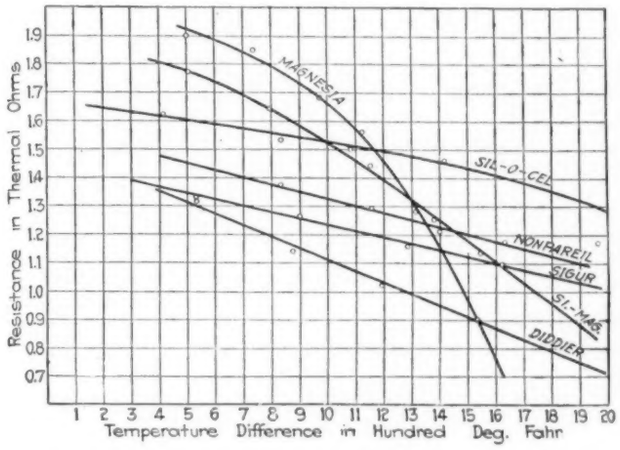


FIG. 9. SHOWING HEAT-RESISTING PROPERTIES OF VARIOUS MATERIALS

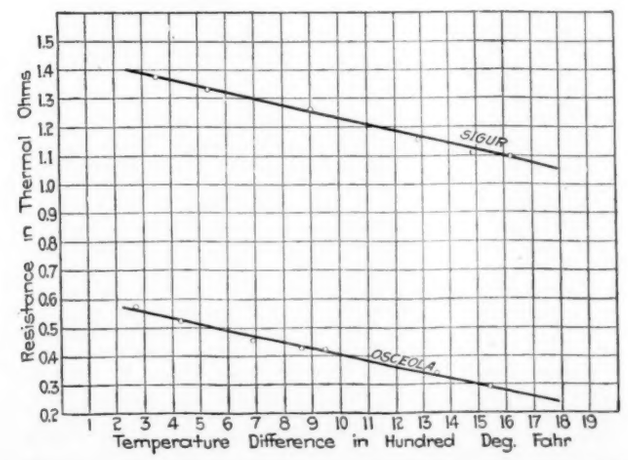


FIG. 10. DIFFERENCE IN HEAT RESISTANCE COMMON FIREBRICK AND SIGUR MATERIAL

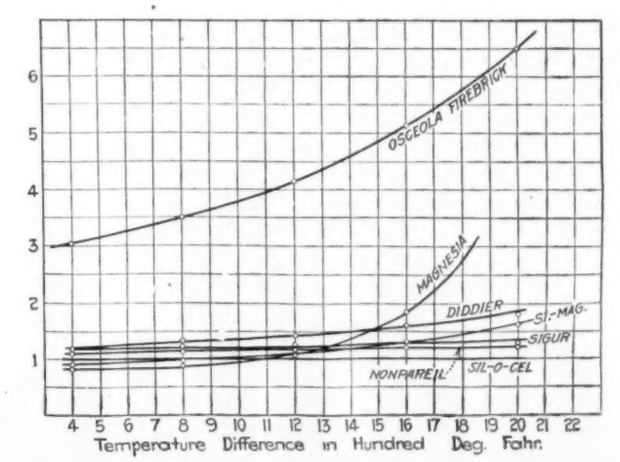


FIG. 11. SHOWING HIGH HEAT RESISTANCE OF NONPAREIL, SIL-O-CEL AND SIGUR MATERIALS

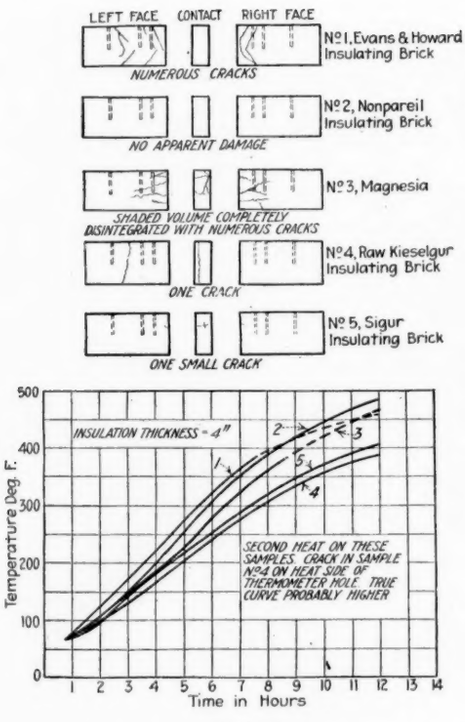

LEFT FACE
CONTACT
RIGHT FACE
No 1, Evans & Howard Insulating Brick
NUMEROUS CRACKS
No 2, Nonpareil Insulating Brick
NO APPARENT DAMAGE
No 3, Magnesia
SHADED VOLUME COMPLETELY DISINTEGRATED WITH NUMEROUS CRACKS
No 4, Raw Kieselgur Insulating Brick
ONE CRACK
No 5, Sigur Insulating Brick
ONE SMALL CRACK
INSULATION THICKNESS = 4"
SECOND HEAT ON THESE SAMPLES. CRACK IN SAMPLE No 4 ON HEAT SIDE OF THERMOMETER HOLE. TRUE CURVE PROBABLY HIGHER
Temperature Deg. F.
Time in Hours

Fig. 12

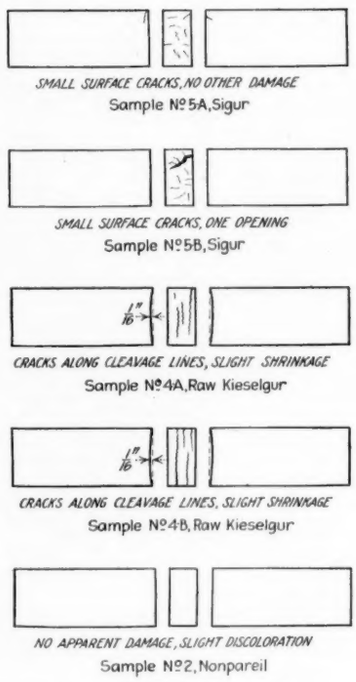

SMALL SURFACE CRACKS, NO OTHER DAMAGE
Sample No 5A, Sigur
SMALL SURFACE CRACKS, ONE OPENING
Sample No 5B, Sigur
CRACKS ALONG CLEAVAGE LINES, SLIGHT SHRINKAGE
Sample No 4A, Raw Kieselgur
CRACKS ALONG CLEAVAGE LINES, SLIGHT SHRINKAGE
Sample No 4B, Raw Kieselgur
NO APPARENT DAMAGE, SLIGHT DISCOLORATION
Sample No 2, Nonpareil

Fig. 13

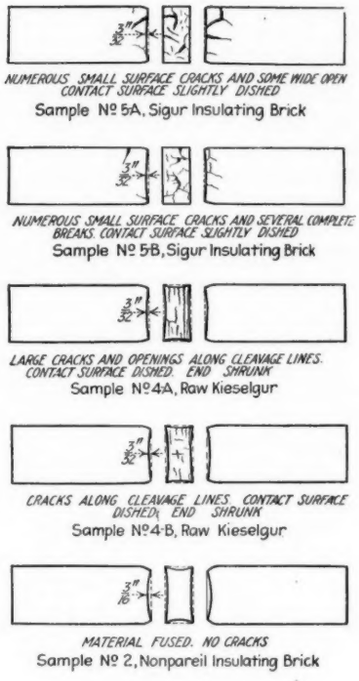

NUMEROUS SMALL SURFACE CRACKS AND SOME WIDE OPEN CONTACT SURFACE SLIGHTLY DISHED
Sample No 5A, Sigur Insulating Brick
NUMEROUS SMALL SURFACE CRACKS AND SEVERAL COMPLETE BREAKS. CONTACT SURFACE SLIGHTLY DISHED
Sample No 5B, Sigur Insulating Brick
LARGE CRACKS AND OPENINGS ALONG CLEAVAGE LINES. CONTACT SURFACE DISHED. END SHRUNK
Sample No 4A, Raw Kieselgur
CRACKS ALONG CLEAVAGE LINES. CONTACT SURFACE DISHED, END SHRUNK
Sample No 4B, Raw Kieselgur
MATERIAL FUSED. NO CRACKS
Sample No 2, Nonpareil Insulating Brick

Fig. 14

FIGS. 12 TO 14. PHYSICAL EFFECT OF HEAT ON THE VARIOUS HEAT-INSULATING MATERIALS

shown on sheets 5B and 6B for a thickness of 2¼ in. of material. As an example, suppose a wall is 4½ in. thick 100 sq.ft. in area, with a temperature difference of 1500 deg. F. An Osceola wall 2¼ in. would radiate 2150 B.t.u. per square foot per hour. From what has been said a 4½-in. wall would radiate 1075 B.t.u. per square foot per hour; therefore 100 sq.ft. would radiate 107,500 B.t.u. per hour. Under similar conditions a sil-o-cel wall would radiate 22,250 B.t.u. per hour, or only about 20 per cent. as much as the firebrick wall.

To secure some data on the physical properties of these materials, tests were run to obtain the information tabulated here:

Name of Material	Weight of Water Absorbed in per Cent. Weight of Brick	Porosity, per Cent.	Weight in Lb. per Cu.Ft.	Apparent Density, Water = 1	Real Density, Water = 1
Osceola	9.3	19.3	129.0	2.06	2.55
Sigur	40.0	55.6	49.4	.79	1.78
Sil-o-cel	166.0	79.4	29.9	.478	2.29
Diddier	147.0	67.8	28.7	.459	1.42
Magnesia	327.0	82.8	15.8	.253	1.47
Nonpareil	96.0	44.5	29.1	.467	.84

It will be seen that many materials absorb considerably more than their own weight of water, showing high porosity, which appears to be an essential property of a thermal insulating material. Because, in practice, these materials have to be handled and subjected to change in temperature, etc., crushing tests were run.

The sil-o-cel, being a natural product, has strata, so tests were run with and against this. This test was repeated on samples after being heated to 1500 deg. F. and allowed to cool. It will be seen there is a small loss of strength due to being heated. Magnesia and Diddier are very weak indeed—the magnesia forming a powder on breaking down. All these insulating materials require careful handling.

To show how the materials behaved when subjected to a high temperature, Figs. 12, 13 and 14 have been prepared. These give some idea of how the materials are liable to crack or warp. These diagrams are made from samples used on the temperature-gradient tests. These

CRUSHING TESTS OF HEAT-INSULATING MATERIALS

Name of Material	Before Heating, Lb. per Sq.In.	After Heating, Lb. per Sq.In.
Sigur	357.6	339.7
Cil-O-Cel with strata	171.6	168.0
Cil-O-Cel against strata	404.4	379.0
Cil-O-Cel average	288	274.0
Magnesia	144	Crumble easily
Diddier	39.3	Crumble easily
Nonpareil	183.0	168.0

results are generally true with the absolute method of test, but though warping was present, cracks were much less.

As these tests required a week or two to complete on each furnace, it was no measure of what effect "aging" would have on the material. For this reason furnaces of sil-o-cel and Sigur were built and run at temperatures of 1200 deg. F. respectively for over six months continually, with no change in the insulating properties whatsoever and with no damage to the materials themselves.

Ground, or Frosted, Glass may be imitated by dubbing the glass over with glaziers' putty. When applied with a light and even touch the resemblance is considerable.

Electric Drive for Battleships "Colorado" and "Washington"—The speedy construction of the warships included in the naval program of the Government is beginning to look very promising. The New York Shipbuilding Co., builder of the new superdreadnaughts "Colorado" and "Washington," has let the contract for the main generating equipment and propelling motors, including auxiliaries for the main turbine generators and smaller auxiliary turbine generator for supplying light and power throughout these ships. The equipments to be purchased are practically duplicates of that contracted for by the Naval Department for the U. S. S. "Tennessee" now being built at the New York Navy Yard. The "Colorado" and "Washington" will be driven by four propellers, as in the case of the "Tennessee," each being driven by an individual motor connected directly to the propeller shaft. The current for the motors will be furnished by two turbine-driven generators. This contract, totaling approximately $2,000,000, has been awarded to the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn.

Vibration Affects Commutation

By M. A. Walker

Some time ago an instance was encountered in a substation where improper foundations under two rotary converters so interfered with commutation that the manufacturer was refused payment for the machines on the basis that they would not operate satisfactorily. Severe sparking occurred at normal loads, the machines shook and made considerable noise, which increased as the load increased. The difficulty had been reported as a case of poor commutation, and a troubleman was sent to the job to remedy the defect.

Poor commutation may be caused by one or more of a multitude of ills, and all of these were attacked one after the other, but with no really apparent effect, after about the first day. The commutator was ground down and sanded, the mica was undercut, the hard abrasive carbon brushes were changed for softer graphite brushes, the brushes were carefully spaced and more carefully staggered and their tension adjusted; the air gap and the resistance of the various windings and between taps were measured; the field-form curves at all loads were taken; the tips and heels of the brushes were beveled and shifted ahead of and behind the neutral for various loads; in fact, everything that could be thought of concerning commutation and commutators was tried. The result was always the same—a suspicion of a change for the better for a day or so while the noise continued, when the conditions again became just as bad as ever. All the old familiar stunts and tricks had been of no permanent avail on the one machine, and the troubleman was called away upon an emergency case before trying his luck with the other and while awaiting instructions from headquarters.

Synchronous Converter Unstable

Having occasion to be in the neighborhood of the substation, I decided to look over the problem and if possible report to headquarters anything of value bearing upon the case. Being imbued with the idea that commutation was the consequence and not the cause of the trouble, from the original complaint and the troubleman's report, and knowing all the other fellow's attempts had been in vain, I decided to tackle the matter from a different viewpoint. The troublesome rotaries were 60-cycle machines supplied over a 40,000-volt transmission line about 30 miles long.

A rotary converter is rather a cranky machine, especially the 60-cycle type, when supplied over a long transmission line. It is well known that a synchronous converter becomes unstable and prone to hunting if the transmission line has a relatively high ohmic resistance and poor voltage regulation therefrom. The instability is further augmented if the field of the rotary is overexcited so that it has a leading power factor.

It was arranged to operate one of the rotaries during the night from one transmission line and to put on and take off suddenly loads that in the day caused sparking and noise. If all went well, it would be proof that the transmission line was at fault, or at least contributing to the trouble, whereas otherwise the cause was elsewhere. There was practically no load on the direct-current side of the rotary at night, which was used for supplying 600-volt street-car service, therefore an artificial load had to be obtained. For this purpose the other machine in the station was run inverted; that is, operated from the direct-current instead of the alternating-current side. Operating a rotary in this way is rather unsafe if compound wound, because if not tied in on the alternating-current side the series winding may overcome the shunt-field flux to such an extent that the machine will race. So long as the alternating-current end is connected to the rotary, thus permitting it to feed back into the system, there is no fear of the rotary attaining excessive speed. However, to be on the safe side the compound winding of the rotary constituting the "load" was short-circuited, though it was feeding into the alternating-current system, and the current taken by it varied by varying the shunt-field excitation. In addition, cables were run to a large water rheostat that happened to be at hand, so as to increase the load still further. With the inverted rotary taking as much current as possible and by suddenly dropping the electrodes of the water rheostat together except for a piece of wood placed between them, so as not to cause a short circuit, the machine on test was given full load, and one that could be varied suddenly or slowly as desired. The converter on test was the only load on the one transmission line, the inverted machine pumping into a second line.

The Effects of Loading the Machine

When all was ready, the operator changed the excitation of the artificial load and brought up the load on the machine under test slowly. Commutation slowly became worse as the noise increased; the load was then applied suddenly by dropping the electrodes close together in the water rheostat. The brushes sparked and the rotary made a noise as if the armature was unbalanced. When the heavy load was thrown on, the floor round the rotary shook and the commutator sparked; the machine made a noise that was not solely due to magnetic vibration, but sounded more like shaking of the foundations. Repeating the throwing on of the load made it evident by touching the frame with the hand that the whole machine shook, and seemed to move when the heavy load was applied suddenly.

Poor Foundations Cause of Trouble

When the load comes on a rotary, if not properly leveled or equipped with an oscillator, the armature has a tendency to move out of the center of the magnetic forces of the field poles. The movement and vibration of the rotary suggested that this was what was happening upon a foundation that was unsteady or unlevel. Going into the basement underneath the machine, it was seen that it was supported upon a steel girder passing directly under the center of the field structure, with two small concrete pillars under each pedestal. The steel girder had been installed as part of the building, but the two concrete columns had been added later. These had sunk, and as a result the machine was partly balanced upon the steel girder. When the load came on suddenly and the armature was pulled over to one side by the magnetic forces, the frame of the rotary moved from one side of the girder to the other. Some steel wedges were driven under the bedplate so that movement in any direction was impossible, the vibration of the floor still continued, but the other rumbling noise disappeared. Commutation was also improved since the wabbling of the armature and the whole machine was partly remedied. After proper foundations had been built under both machines, their operation became normal and no more trouble was experienced from poor commutation.

Steam-Engine Troubles—Operation—II

By H. Hamkens

SYNOPSIS—This, the last article of the series, deals chiefly with the adjustments that must be made to a newly erected engine, although they are necessary to an old engine. Speed regulations, so essential to good service, is here treated of. The bearing surfaces of a new engine must be carefully watched and properly attended to to avoid serious trouble at a time when it is most undesirable to shut down. The article tells how.

The speed fluctuation of an engine should be confined between certain limits. This is easily attained for steady loads, but for sudden and great variations of load, special features must be incorporated in the design. The first consideration in this respect is the flywheel, which must be heavy enough to give a uniform motion. It should compensate for the impulse of the steam on the piston during admission and the gradually decreasing pressure during expansion. It must also neutralize the varying effect of the crankpin effort, never the same at any two consecutive moments, and be able to overcome shocks due to instant changes in the load.

Governor Regulation

The governor can begin to act when a change in the velocity of the wheel has taken place, only after one-half of a revolution is completed, when it will admit more or less steam for the next turn, or stroke. Its object, therefore, is to regulate the amount of steam necessary to keep the shaft and wheel revolving at a certain speed. To what degree of uniformity a governor will regulate the speed of an engine depends on its sensitiveness. Most Corliss-engine governors are provided with a sleeve that moves up and down on a vertical spindle; different positions of the sleeve represent different speeds of the engine. For comparatively steady loads this motion may be utilized to indicate variations in speed, by placing a graduated scale on the governor column with a hand on the lever pointing to it, as shown in Fig. 210, and marking the scale for certain speeds by timing the engine with a watch; but for fluctuating loads and accurate observations a tachometer driven by a belt from the shaft should be used.

Revolution counters cannot be used to show fluctuations of speed; they will only record the number of revolutions that an engine makes during a certain length of time without regard to varying speeds. A recording and indicating tachometer will show the speed of an engine at any moment and also produce a written record on a chart, showing the time of starting and stopping and indicating the fluctuations during 24 hours.

On single-cylinder and tandem-compound engines the instrument can be conveniently driven from a pulley fastened to the end of the shaft, as shown in Fig. 211. This enables the engineer to make a speed test by throwing on the tachometer belt, but on cross-compound engines it is troublesome to connect the driving belt when the engine is running. However, if the speed variation of an engine has once been noted and recorded for a certain length of time and different loads, that will serve as a guide unless some important changes in the valve gear and governor connections have been made since the speed was last tested.

On direct-connected engines fluctuations in speed will also produce a change in voltage. This, however, is not so reliable as a test with a tachometer, since the voltage may also be affected by varying loads of the generator. Recording ammeters and wattmeters afford a convenient and accurate way of keeping records of the load conditions in power plants using direct-connected unit exclusively, but indicators and tachometers are of equal importance to keep a check on the performance of the engines. It apparently requires a lot of attention to regulate the performance of an engine, but if a system is once established with a regular routine, it will be found that the work is not only simple, but also interesting.

Examine New Engine

After a week's run a new engine should be thoroughly examined. The valves should be taken out and the high spots "touched up" with a fine file or scraper. The back head must be removed for an inspection of the cylinder bore; if there are signs of cutting, the affected part must be scraped smooth and the junk-ring and the packing ring taken out and carefully smoothed with a file. The crosshead and crankpin and their boxes should be inspected; if there is any indication of wear or of binding, the boxes must be rescraped and relieved. The effective working surface of the boxes is only about 85 per cent. of their projected area; the balance near the parting is of little use—in fact, it may be the cause of pinching and heating the pins. The boxes should therefore be relieved at these places, as shown in Fig. 212. This will also allow the lubricant to spread freely over the pins. Before unscrewing the wedge bolts, their position should be marked on the connecting-rod to bring the wedges back to the same place. If a new adjustment is necessary, the wedges may be screwed tight and then backed off to give the boxes sufficient clearance. In most connecting-rods the taper of the wedges is $\frac{1}{8}$ in. per inch; if 1-in. bolts with eight threads per inch are used, one turn will adjust the boxes $\frac{1}{64}$ in. With proper marks on the heads of the bolts and on the rod, a close check can be kept on the adjustment.

Babbitting Boxes

The crankpin boxes must be lined with babbitt of the best quality. For this purpose the recess in the castings must be thoroughly cleaned, scraped and tinned. Before the babbitt is poured the boxes must be heated, and after cooling it should be expanded by hammering. Babbitt poured into boxes not previously tinned and heated is liable to shake loose and break into small pieces. Genuine babbitt is composed of 3 parts copper, 89 parts tin and 8 parts antimony—an expensive mixture, but the extra expense will be saved over and over again through its excellent wearing qualities. Inferior grades of anti-friction metal are principally composed of lead; they wear rapidly, unless the pressure per unit of surface is low. On babbitted boxes no other part except the babbitt must come in contact with the bearing surface of the pin.

The best way to oil a crankpin is from the center by means of a centrifugal oiler, as shown at *A*, Fig. 213, with one hole in the middle of the pin pointing inward to the center of the shaft. If the pin is long and two holes are desired, each must have a separate oil supply, as shown at *B*. The two holes must not be connected, otherwise the first one will take nearly all the oil and none will reach the other. The reason for turning the hole toward the center of the shaft is obvious, if we consider the four positions of the crankpin shown in Fig. 214. The pressure transmitted from the piston to the crankpin affects, during one revolution, only about three-quarters of the circumference, as indicated in heavy lines in the sketch. wear almost entirely on one side provided the engine runs always in the same direction.

The crosshead pin should have the oil hole on the top, as shown in Fig. 215. The upper and lower sides of the pin should be flattened for two reasons: First, to make the oil spread over the length of the pin and, second, to prevent the brasses from wearing shoulders on the pin, owing to the oscillations of the connecting-rod. On large engines with heavy rods, where the wear is considerable, the amount of flat must be carefully determined. If the oil supply is liberal, as it will be if a continuous oiling system is installed, oil grooves in connecting-rod boxes are superfluous; but where the oiling is done by drop feeding

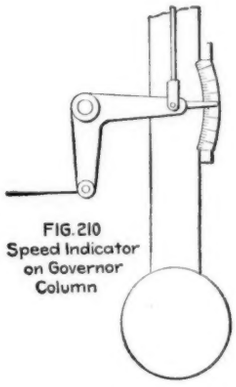


FIG. 210 Speed Indicator on Governor Column

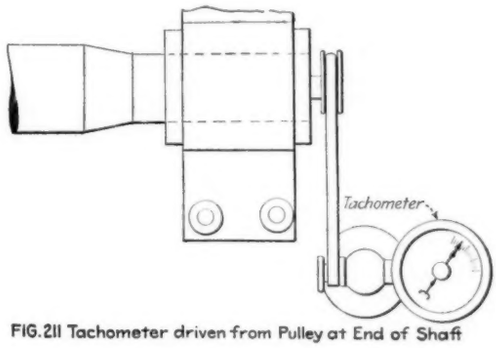


FIG. 211 Tachometer driven from Pulley at End of Shaft

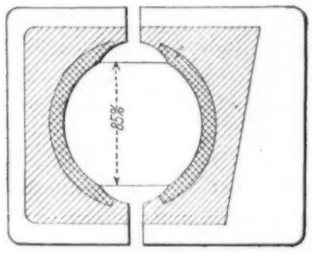


FIG. 212 Crankpin Boxes relieved to allow for Wear

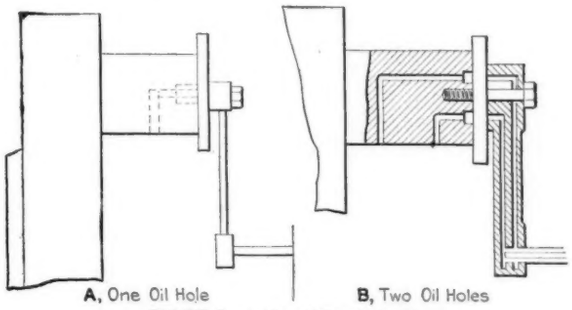


FIG. 213 Centrifugal Crankpin Oilers

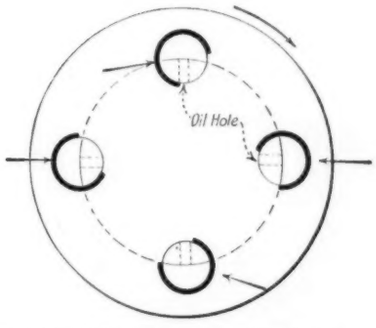


FIG. 214 Crankpin Surface exposed to Wear

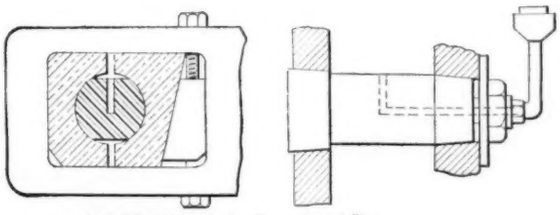


FIG. 215 Oil Hole in Crosshead Pin

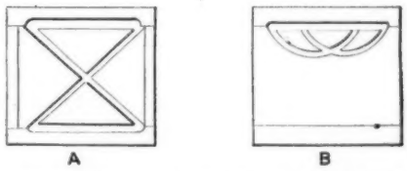


FIG. 216 Oil Grooves for Crankpin and Crosshead-pin Boxes

FIGS. 210 TO 216. SPEED INDICATORS AND LUBRICATION PROVISIONS FOR PINS AND BOXES

The part of the pin shown in light lines hardly ever comes in contact with the boxes, and since it offers the least resistance to the flow of the oil, the oil hole should be located within its limits. The most convenient direction is toward the center of the shaft, which makes it right for the engine running over or under. On crankpins with the oil hole drilled toward the outside oil can flow through only when the hole passes the split in the boxes near the upper and lower centers, in which case the centrifugal force will throw most of it against the rod and out at the sides without taking effect in the pin or the boxes. Pins oiled in that way require a large quantity of lubricant. Incidentally, the sketch shows that a crankpin will from oil cups, grooves will improve the distribution of the oil. In crankpin boxes lubricated by means of a center-oiler, the grooves should run crosswise, as shown at *A*, Fig. 216, while the crosshead pin boxes should be grooved only on the upper side, as shown at *B*. The object of oil grooves is to distribute the lubricant over the width of the boxes and to retain part of it for a while. It must be borne in mind that they are also likely to collect dirt, which must be removed from time to time, otherwise they will be worse than useless.

The shells and quarter-boxes of the main and outer bearings should be examined after the engine has been run several days, and if they show unequal wear they

must be lightly rescraped. It is not only a needless waste of material to babbitt the caps of main and outer bearings the full length on horizontal engines, but also a detriment to efficient lubrication. There is no tendency for the shaft to lift, therefore a narrow strip at each end will be sufficient to keep it in place. The wide space between the two strips and between cap and shaft makes it possible for the oil to spread over the whole surface and lessens the danger of dry places being formed. If the edges of the quarter-boxes and lower shells are well beveled, there is no need of oil grooves. Some engine builders state that the lower shell of the main bearing on their engines can be removed "by lifting the shaft a fractional part of an inch," which is a vague expression. If it means that the shaft has to be lifted $\frac{15}{16}$ in., for instance, that would be unsatisfactory, since it would in many cases involve quite an expenditure of time and money; $\frac{1}{8}$ in., or, on large engines, $\frac{1}{4}$ in. should be the highest lift required for this purpose. An engineer will do well to investigate this matter before an engine is accepted.

Engine Adjustment

Any part that has been adjusted must be watched closely for a while, and the engineer must be prepared for an emergency. One of the most disagreeable things that can happen is a hot pin or bearing. On a new engine this may come quickly and not much time can be lost in applying remedies. If the crankpin gets hot, it should be flooded with oil through the center-oiler; should the heating continue, the engine must be slowed down and the wedge backed off. The same thing should be done if the crosshead pin heats unduly. On main and outer bearings the capbolts should be loosened, the quarter-boxes backed off, and plenty of oil poured on the shaft.

Light oil has no lubricating effect on hot surfaces. It is therefore of little use on a hot bearing or pin except to carry off some of the heat if used in considerable quantities. To be beneficial it must be mixed with cylinder oil, but cylinder oil alone is to be preferred. Filtered water mixed with oil may be used for cooling, but never hydrant or well water that contains grit, which would embed itself in the surfaces and quickly ruin them.

Cooling Hot Boxes

It is dangerous to throw water over or "turn the hose on" the connecting-rod and boxes if the crosshead pin or crankpin gets hot; they will contract if suddenly cooled and close in on the pins pinching them that much tighter, which may result in a serious breakdown. The cooling process should be done from the inside to make the pins cool first. If the babbitt begins to run, the engine must be turned over slowly but not stopped suddenly, otherwise the babbitt will "freeze," making it difficult to remove the boxes or shells. The engine must be kept moving and the hot parts cooled until the babbitt is safe, when the engine may be shut down and examined. It depends, of course, on circumstances whether it may be started again without removing the parts affected, or whether they must be taken down and overhauled or even rebabbitted and refitted.

Compound engines are cared for much the same as simple engines. In a cross-compound, two engines are connected to one shaft, while in a tandem-compound both cylinders have a piston rod, crosshead, connecting-rod, frame and crank in common. The object of compounding is to attain better economy by the use of higher steam pressures, a greater ratio of expansion and reduced cylinder condensation. The steam is expanded in two cylinders, which lessens the range of temperatures in each of them. Steam has the tendency to give up heat the moment it strikes a colder surface, which is the cause of much loss of steam in single-cylinder engines running with high steam pressure.

Assuming, for instance, an initial pressure of 150 lb. gage with a temperature of 366 deg. F., if the engine exhausts against one pound back pressure, the incoming steam will come in contact with surfaces which have been exposed to a temperature of 216 deg. F., a difference of 150 deg., provided there is no compression. Now if the process is carried out in two cylinders, one high- and the other low-pressure, the temperature in the high-pressure cylinder will range between 366 and 285 deg., with a difference of 81 deg., and in the low pressure betwen 276 and 216 deg., with a difference of 60 deg. If a condenser is used, the single-cylinder engine will be at a greater disadvantage. Compression will reduce initial condensation, but it weakens the engine so that for the same load more steam has to be admitted. The question whether it is more advantageous to increase the compression and extend the cutoff, or to reduce the compression and lose steam through initial condensation, can in many cases be decided only by the coal pile.

Most Economical Results

An interesting problem for an engineer is to find out under what conditions an engine will give the most economical results. Proper records will enable him to notice when peak loads or light loads occur and during which periods the load is normal. If there is any regularity in the changes of the load it will be possible to make careful tests as to steam consumption and to regulate the boiler pressure to suit. A high boiler pressure is not always the most economical; in fact, on a light load it may be wasteful. Neither is it good practice, as some people think, to overload an engine. If an economy test is made on an engine it should concern only the engine itself and not the evaporation and leaks of the boilers or the condensation in the steam pipe, which can be taken into account only in a test of the whole power plant or of each individual part. In a Corliss engine there will usually be quite enough compression from this point of view if sufficient is used to give the necessary cushioning effect.

Dressing to Prevent Rust—Dissolve one part of resin in three parts lard or oil.

Corrosion Research Committee—A reconstitution of the Corrosion Committee of the Institute of Metals, of Great Britain, has been effected during the past year, half the members now being appointed by certain government departments and by certain technical societies specially interested in the subject under investigation. Prof. H. C. H. Carpenter is chairman of the new committee, to which a grant of £325 has been made by the treasury. A condition of this grant was that a salaried investigator should be employed, and Capt. G. D. Bengough has been appointed to the post, with Dr. O. F. Hudson as assistant investigator. The government grant is to be raised to £900 per annum. With the help of J. Christie, an experimental sea-water corrosion station has been established at the Corporation Electricity Works, Brighton, where condenser tubes are being tested under actual working conditions. Especial interest attaches to this plant, as the power station condensers are fitted with the Cumberland protection system.—"Engineering."

Steam Engineer's License Examination—IX

By H. F. Gauss

SYNOPSIS—Leaky valves as a source of loss. Features of the poppet valve and methods adopted to prevent leakage.

There are two sources of excessive loss in the average steam engine. One is by leaky valves, the other is by initial condensation. The first will be considered here, the second later on. Leaky valves may be due to one or more of numerous causes. The valves may be poorly fitted; they may be badly worn; they may not have the proper seal; they may be tight under one condition of temperature and pressure and leak under another. Each of the causes mentioned suggests its particular remedy except the last. This last condition obtains when the valve and seat, including the balancing device, do not expand and contract equally when the temperature to which they are exposed changes. This is due to a different quality in the material of which they are made. Thus the valve may be tight at one temperature and leak at another, or a valve may be tight when using saturated steam and may leak badly when using superheated steam. The defect must be corrected by proper design, that is, some provision must be made for the valve to adjust itself to variations in expansion of its various parts and seat.

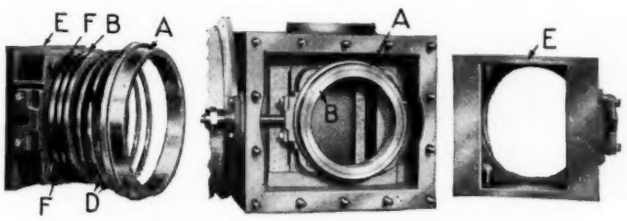


FIG. 1. STEAM-TIGHT BALANCED VALVE

A valve designed to be steam-tight under all conditions of pressure and temperature is shown in Fig. 1. This is a balanced valve similar to the type described in a previous article, with the provision, however, of automatically taking up any wear that may occur in service or any unequal expansion of its parts. The construction is simple and self-evident. Referring to Fig. 1, *A* is a sleeve that fits over the cylinder *B*. The cylinder is cast integral with the main valve body *E* and is grooved for packing rings *D*, which prevent the leakage of steam between it and sleeve *A*, which is held out against the steam-chest cover by the four spiral springs *F*. The space included between the steam-chest cover and the inside of the cylinder *B*, forms the exhaust chamber. This valve has been known to remain tight throughout long periods of service and has undoubtedly been a means of maintaining good economy.

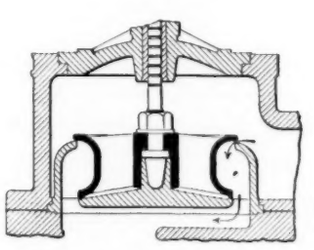


FIG. 2. VALVE EXPANDED MORE THAN SEAT

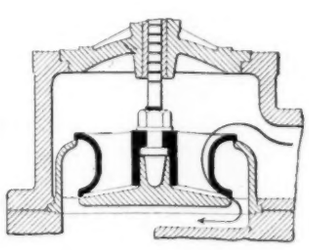


FIG. 3. SEAT EXPANDED MORE THAN VALVE

While doubtless some method must be devised to provide for unequal expansion and wear, a multiplicity of parts is undesirable. Packing rings become clogged with a carbon deposit from oil, unless care is taken to be sure the proper grade of oil is furnished and used. When it is considered that in an engine running 275 r.p.m. the valve makes 330,000 strokes in a 10-hour run, it is realized that the lubrication of the sliding surfaces becomes a problem. The present-day tendency toward increased steam pressure and higher superheat renders these difficulties more pronounced.

The poppet valve has been developed to overcome these difficulties. All sliding and rubbing of the valve on its seat is eliminated, consequently the valve seats are not subject to this wear, and the valve is more likely to remain tight. Most poppet valves are arranged to turn through a small angle each time they seat. If they do not, localized wear may occur which will cause leakage in case for some reason the valve happens not to seat in the same place.

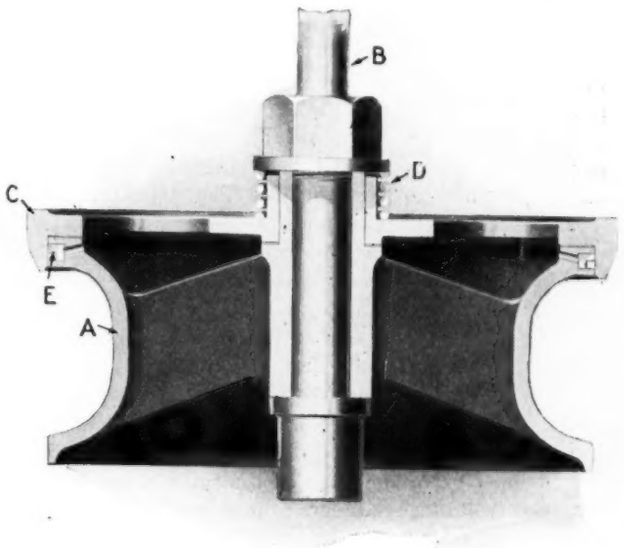


FIG. 4. TWO-PART POPPET VALVE

The simple double-beat poppet valve can be perfectly balanced, and when carefully fitted and ground in, will remain steam-tight through a long period of operation, provided the temperature to which it is subjected does not change. However, if the temperature changes because of a variation in steam pressure or superheat, the valve proper will expand at a different rate than its seat, or cage, and a steam-tightness no longer obtains. Thus, Fig. 2 is a diagram of a poppet valve in which the valve has expanded more than the seat, the result being that in the closed position the bottom seat is tight and the top open slightly, the leakage being indicated by the arrow. Fig. 3 is a diagram of a poppet valve in which the seat has expanded more than the valve, and the result in this

case is that in the closed position the top seat is tight and the bottom seat open slightly.

Among the various means adopted to prevent the valve leaking from unequal expansion are two worthy of special mention. One is to cast the valve and its cage of the same metal. They can even be cast in the same flask and broken apart for machining. This method is effective, and when care is used to insure the maintenance

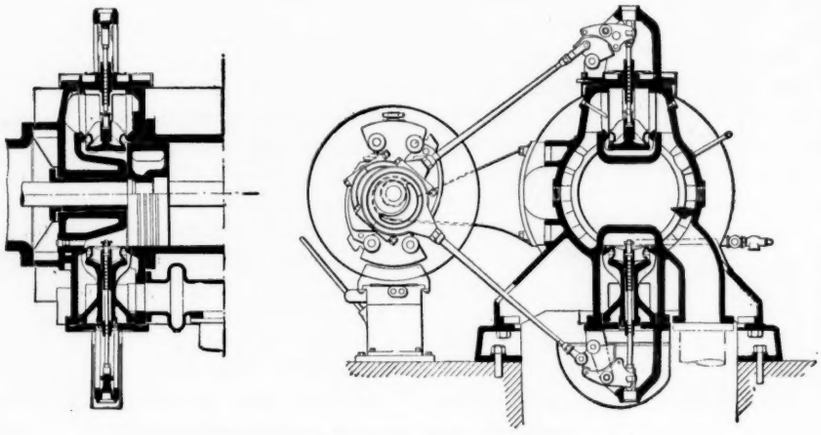


FIG. 5. FULL POPPET VALVE ENGINE

of tight joints between the cage and the cylinder body, a tight valve is secured under all conditions. Another method is shown in Fig. 4. The valve is made in two parts. The main body *A*, carrying the lower seat, is fastened rigidly to the stem *B*. The upper seat *C* is a separate casting held in place on the main body by the spring *D*, shown under the nut. This upper seat is arranged to telescope over the top of the valve body, leakage of steam through the joint being prevented by a packing ring *E*. The valve is so designed and proportioned that the upper part seats first and the spring then compresses enough to permit the lower part to seat.

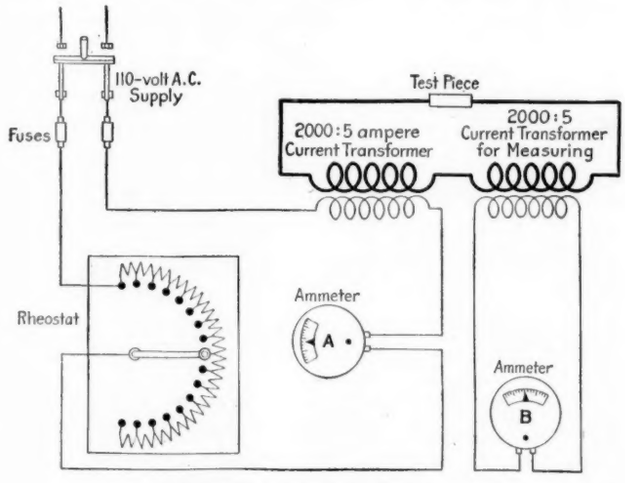
Fig. 5 is a section of a full poppet-valve engine. The special features to be observed are: Simple valve gear; poppet valve and cage of the same material; small clearance volume; cylinder proper practically a heavy pipe cast separate from the heads; the valves in the cylinder heads with the stems vertical and not subject to excessive wear.

Heavy Current from Current Transformer Inverted

By R. K. Long

Sometimes it is necessary to obtain a comparatively heavy alternating current for a short period of time when there are no facilities for generating it and where the only source of energy available is the usual commercial circuit with a limited kilowatt capacity. Some instances of such applications are when it is desired to determine the temperature rise of a splice, the blowing of a large-capacity fuse, the current required to operate a heavy-current relay or the heating of oil-switch contacts at a definite amperage. In these cases it is not high energy, but only high current, that is needed, and for such tests the use of the current transformer offers a convenient way of obtaining the desired result, and often the only possible way in which this can be done.

While the current transformers are generally used to change a large current to one of small value for metering purposes, the device is equally applicable for transforming a small current to a heavy one so long as the resistance of the circuit comprising the high-current side is low. As the capacity of current transformers is invariably low, irrespective of the current, the resistance of the heavy-current side must be very low since the capacity in watts is expressed as the product of amperes and volts. It is always important, when using a current transformer inverted, to have a minimum resistance in the heavy-current circuit, since the temperature of the conductors will increase materially, which will cause the resistance to increase and it may be necessary to discontinue the test because of being unable to maintain the current at the desired value. For a test with 2000 amp. a current transformer rated at 2000 to 5 amp., or a ratio of 400 : 1, is needed. Also a rheostat must be connected in the 5-amp. side of the current transformer, as shown in the figure, to permit controlling the current. The ratio of transformation of a current transformer, in this case 400 to 1, does not hold accurately or even closely when operated inverted, therefore, a meter reading taken as at *A* times the transformer ratio will not give an accurate indication of the current in the test circuit. If possible, another current transformer of the same ratio and current-carrying capacity should be used, to which an ammeter *B* is connected as shown. The function of this second transformer and meter is to give an accurate measurement of the current. While bringing up the current, it is well to use a low-reading voltmeter across the low-current side of the current transformer so as to show what voltage is applied across the winding. This voltage should not exceed that required to give the rated capacity of the transformer when multiplied by the current by more than 50 per cent. The success with which a current transformer can be used for this purpose depends upon whether the resistance of the heavy-current circuit is sufficiently low; therefore, use ample cross-section of conductor.



TEST CIRCUIT CONNECTIONS

Editorials

The Enemy Within

The battle is not to the strong alone. In the great world war in which America is to take a belated but decisive part, it is not the uniformed forces and the military equipment alone which are to win the fight. The resources of the peoples of the world are pitted against one another. It is an industrial war. So long as a nation has materials at its command and can continue to support its people at home as well as the army at the front, so long will it be a factor in the struggle. The more effectively it can do this the more potent factor it will be, and when either side can no longer do this it must lay down its arms and sue for peace.

America, removed as it is from the clashing fronts of battle, has so far little to fear from the enemy from without. With our financial, material and industrial resources it must be our task to support our devastated allies, to restore shipping faster than Germany can destroy it, to supply those who are fighting our assailants with the necessities of their industrial as well as their corporeal life. We must raise more food, we must mine more coal and more metal, we must manufacture more products of all kinds than ever before, and this at a time when the already restricted supply of labor is depleted by the call to arms.

There must be no failure to realize the magnitude and the vital import of the task, there must be no delay in mobilizing the forces of agriculture and mining, and industry, and transportation. We must not find out in the summer what ought to have been done in the spring. There must be no real scarcity of any necessity that human foresight and ingenuity and intelligently applied industry could have produced. An artificially created scarcity, local or general, for the purpose of enhancing prices, reprehensible enough at any time, becomes an intolerable atrocity which should be summarily dealt with. The war will bring enough real hardships and sacrifices without being made the excuse for further extortion. The workers winning the war must be protected against any unavoidable impairment of the purchasing power of their day's work.

On the other hand, labor must not take advantage of its essentiality. Not only must there be no interruption to production and distribution by strikes, but the efficiency of the industrial system must not be impaired by the refusal of labor to do its part in speeding up the system. Henry L. Gantt, a recognized authority, estimates that the present industrial outfit of tools and machinery in the United States could, with intelligent adaptation and management, and the willing coöperation of their operators, be made to produce four or five times the present output. Whoever takes advantage of existing conditions to counsel labor to refrain from showing what it can do to win the war for fear of setting new standards of capacity, whoever counsels strikes which, in addition to impeding output, will furnish opportunities for the exercise of that violence against our institutions and resources which sympathizers with the enemy are only waiting for a chance to exert, should be credited with sinister motives and treated as are those who give aid and comfort to the nation's foe.

The Refillable Fuse

Within recent years refillable fuses of several designs, both of the cartridge and the plug type, have been placed on the market by different manufacturers. Although these devices have not, up to the present time, been approved by the National Fire Protective Association, their performance under test and in actual service has been such that they have attracted considerable attention in their favor.

The object of a fuse is to protect a circuit from being overloaded. This end is frequently defeated either through carelessness or ignorance by over-fusing the circuit. Sometimes this is practiced by placing a fuse of too large capacity and sometimes by bridging the fuse after it has blown. Many are the schemes that have been brought into use to accomplish this end, with fuses of the nonrefillable type. They have been bridged by fuse wire of most any capacity, either by soldering it to the fuse ferrules or by flattening the ends of the fuse wire and placing them between the fuse terminals and the clips. When fuse wire was not at hand, copper wire, nails or any other conducting material that happened to be convenient was pressed into service. Not infrequently with plug fuses, iron washers and even pennies have been placed in the bottom of the sockets and the plugs screwed back into place.

It is a general practice of the workmen who doctor up a fuse, to try and cover up the defect if possible by placing the conducting material back of the casing, where it cannot be easily detected. This tendency to cover up wrongdoings should be in favor of the refillable type of fuse. If the practice as carried on with the nonrefillable type cannot be discouraged, it would seem that by placing the filling inside of the cartridge, at least part of the hazard would be eliminated; namely, if the fuse does blow the arc will be confined. On the other hand, there is the question, Will the use of refillable fuses encourage the abuse, already existing, of over-fusing the circuits? Experience has shown that the refillable fuse is not always filled with standard fillings; nevertheless, evidence collected from operating conditions shows that there is less tendency to abuse the refillable than the nonrefillable type. Probably one of the chief causes of over-fusing with the nonrefillable type is the difficulty experienced by repairmen to carry around a sufficient number of fuses to meet the various conditions that he may come in contact with. No doubt this difficulty would be eliminated to a large extent with the refillable type; however, with the many different designs on the market at the present time this advantage is largely offset.

The Bureau of Standards was called upon to investigate the refillable fuse and in some cases found that it

was capable of protecting the circuit under more severe conditions than some of the approved nonrefillable types. However, the deterioration due to repeated blowing of the fuse in the same casing was regarded as an undesirable feature. The bureau, after an extensive consideration, did not render a decision on account of not having sufficient data on the device under operating conditions. This is practically the recent decision of the Switch and Cutout Committee of the National Fire Protective Association: "The evidence presented or obtained by the committee does not warrant it in recommending any change in Rule 68d," which in part is, "The fusible wire must be attached to the terminals in such a way as to secure a thoroughly good connection and to make it difficult for it to be replaced when melted."

Stop Waste, But Encourage Business

The war is going to cost a lot of money, the credits just voted by Congress having run into figures heretofore undreamed of. This will mean heavy taxes, and when taxes are heavy the tendency is to retrench. But, as Howard Coffin cautioned in a recent interview, there is grave danger of carrying this tendency to the point of hysteria, with consequent harm to the nation. One should not confuse the elimination of waste with curtailment of production or needed expenditure, but as one has aptly put it, let us strive for "efficient patriotism."

The burden of taxation can best be met by healthy business conditions with plenty of money in circulation, and to maintain such conditions in the face of a great conflict demands the sober judgment of the business men of the country. While the needs of the Government have first claim on our industries, let the managements not rest there, but strive to foster and supply a demand for all surplus production. Then and only then will the country be best fortified to meet the exigencies of the war and the readjustment of conditions that are likely to follow the reëstablishment of peace.

Heat-Insulating Materials

Few subjects are of greater interest to engineers than that of heating-insulating materials. In this issue are given the results of tests by a prominent firm of engineers, of several materials of this character. The materials were formed into bricks, and small furnaces made of the latter, the furnaces being heated by arc-lamp resistance coils. The heat input to the furnaces, though measured in electrical units, was converted into British thermal units. The use of electrical heaters gave far better regulation and flexibility than is possible with the gasoline torch.

The decrease in thermal resistance of magnesia with increasing temperature is interesting. The reason given for the falling off of the heat-resisting properties of this material at high temperatures is that at these temperatures a chemical change occurs in the material, resulting in its disintegration. The point is brought out that when subjected to low temperatures, it is only a matter of time before disintegration of this material takes place.

The article shows that the materials tested are considerably superior to ordinary firebrick for heat-insulating purposes and, further, that physically most of them well resist the disintegrating influence of continued exposure to heat.

Auxiliary Steam-Plant Equipment

The extent to which it pays to spend money in high-class equipment for auxiliary steam-plant service is often debated. Not long since the opinion was advanced generally that any old set of boilers and engines is good enough for carrying short peak loads or for stand-by intermittent operation. It was very properly pointed out that the total peak-load output in kilowatt-hours in an electric plant is generally relatively small where such a plant is a steam-driven station tied in for short service as an auxiliary to a hydro-electric system of reasonably ample water-power capabilities. "Why, then," said the advocates of low first cost, "should anything but the least expensive equipment be provided for such a station? Let the generators be second-hand units with a history dating far back. Cut out the condensers if necessary, to reduce the investment, and let the station layout be such that the cost of the building will be the lowest possible for the capacity installed. Spend as little as possible on switchboard equipment and, finally, take no thought of the morrow as respects the growth of the steam station, for are there not ample water powers in the valley whose rights are controlled by the company?"

This viewpoint still has some adherents, but it overlooks the all-important question of "service." Admitting that an auxiliary steam plant is one of the most hopeless propositions to handle efficiently, and granting that some conscientious engineers simply haven't the courage to figure the unit cost of production in such stations so poor is the load factor and so hard is it to avoid wasting practically all the heat units in the fuel under stand-by boilers, does this justify installing the cheapest possible layout of equipment? There can be but one answer to this question, if the service rendered by the station when it does deliver power is of real value.

The best equipment that the company can afford is none too good for reliable production under peak conditions, in the opinion of the experienced operator of auxiliary steam plants. Hydro-electric companies that have lately built such stations to supplement their water-power plants have done well to equip them with efficient condensing turbine or engine sets, first-class boilers and well-selected auxiliaries.

Many vessels engaged in coastwise shipping will go into transatlantic service. Coal freight rates, which have for long been high, will likely go much higher, and will further increase coal prices. Coal is so fundamentally essential to the carrying out of our duty in the present crisis that nothing should be left undone that will expedite the delivery of adequate fuel to our industries.

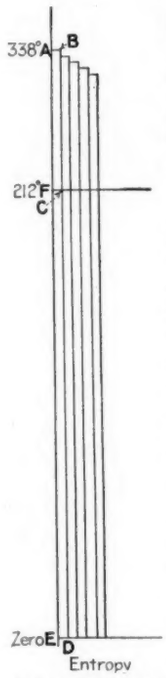
The expert appointed to investigate an electric company which lowered rates but presented larger bills advised the customers to use reflectors and save light—which recalls the committee whose profound researches into the causes and possible remedies for the high cost of living resulted in the sage admonition if meat is high—to eat fish.

From our English contemporaries it would appear that several of the engineering societies in England are seriously discussing the metric system. Is it not time that some of our own national societies follow the popular slogan "Wake Up America?"

Correspondence

Energy Released by Boiler Explosion

It is a very interesting question raised by Mr. F. R. Low in his article, "Energy Stored in a Boiler Under Pressure," in *Power* for Apr. 10, 1917, and its accompanying editorial illustrates very clearly how the testimony of experts may be widely different and yet entirely honest. Perhaps it may help clear up the question to remember that though we speak of an instantaneous release of pressure and a consequent "flashing" of water into steam, in the actual event the drop in pressure is gradual, though perhaps rapid, and the contents of an exploding boiler undergoes all the pressure and temperature changes that were passed through in firing up, though in the reverse order. Consider what actually happens when a boiler under 115 lb. abs. ruptures. With the first release of pressure innumerable minute bubbles of steam form throughout the mass of the water, and with subsequent decrease of pressure the steam so formed expands adiabatically, driving the water out of the way. This may be represented on the entropy-temperature diagram as follow: For the small drop under consideration the temperature may be considered constant, so the heat used in vaporizing the small amount of steam is represented by the rectangle *ABDEA* and its adiabatic expansion would be along the line *BC*, and when equilibrium is reached at 212 deg., the heat content is represented by rectangle *CDEFC*, the heat represented by rectangle *ABCFA* having been changed to work and utilized, either to wreck the surroundings or to impart velocity to the mixture of steam and water or to the steam itself.



ILLUSTRATES GRADUAL DROP

With the next drop in pressure, more steam is liberated at the lower temperature, and its heat history is shown by the next rectangle to the right. By making these steps infinitely small, the top line would approach a smooth curve, and with the pressure drop continuous, the figure would in fact be identical with Mr. Low's temperature-entropy diagram in Fig. 5 except for reversal, which means only that in one case the heat is absorbed by *water* during a rise in pressure and temperature and in the other by *steam* during a corresponding drop in pressure and temperature.

Now in the figure, *ABCFA* is the cycle of the perfect heat engine, the Carnot engine, and the foregoing reasoning shows that the 10.8 B.t.u. heat area above 212 deg. in Mr. Low's Fig. 5 (shaded) can be conceived as utilized in a vast number of perfect heat engines during an explosion or other release of pressure.

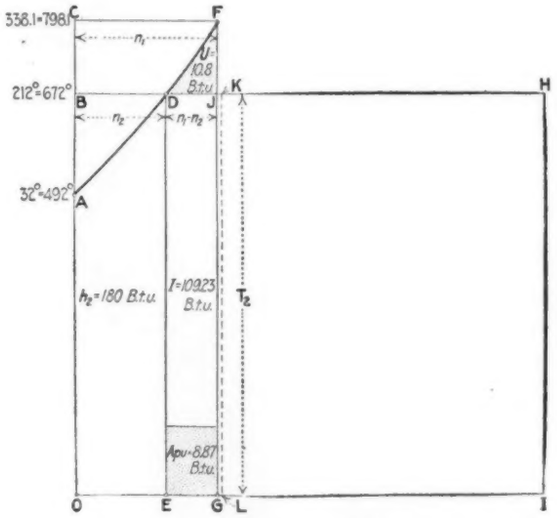
The question raised by Mr. Low may be stated in this way: What is the limit of the efficiency of a boiler explosion, considered as a heat engine? The foregoing analysis indicates that the heat added to the water in the boiler in heating it from 212 deg. F. to boiler temperature can be utilized at the efficiency of a perfect (Carnot) engine *between the temperature at which it is added and 212 deg. F.* The engineer can hardly ask for more than this, and as the amount of heat which it is possible to change into work on this basis is 10.8 B.t.u., that is the limit of available energy in an explosion under the conditions given.

This is based on the assumption that the mass of released material approaches equilibrium at 212 deg. F. As a matter of fact the steam is discharged immediately into the air at a much lower temperature and some of it is at once condensed, losing almost all of its volume. This has a tendency to increase the available energy. In terms of the temperature-entropy analysis it makes the lower temperature limit less than 212 deg. F., so that *CF* in the figure would be farther down on the temperature-entropy diagram.

The physical conception would be that as some steam was condensed while other steam was forming, the volume never reaches the theoretical maximum so that the energy necessary to displace the atmosphere never reaches the full value *Apu*.

G. W. MUNRO,
Asst. Professor of Mechanical Engineering,
La Fayette, Ind. Purdue University.

I cannot see any reason why the "doctors" should disagree in this case. It should be clear that the results of ten to eleven available heat units per pound are correct



TEMPERATURE-ENTROPY DIAGRAM FOR WATER BETWEEN 338 AND 212 DEG. F.
Fig. 5 of original article

and that the solution offered is satisfactory. In other words the area *DFJD* in Fig. 5 of the original article (here reproduced) is the area available, the heat under

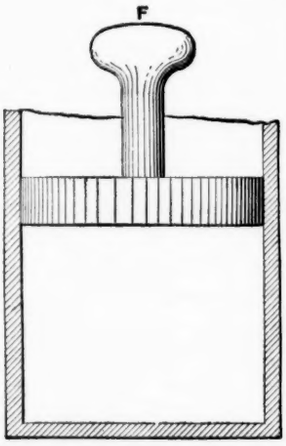
the line *DJ* being held mechanically inactive by the pressure of the atmosphere upon it.

ARTHUR W. COLE,
Assoc. Professor of Mechanical Engineering,
La Fayette, Ind. Purdue University.

---

1. The maximum amount of energy liberated by expansion of hot water is liberated when expansion is isentropic.

2. For 1 lb. of water at 338.1 deg. F., expanding isentropically to 212 deg. F., this amount of energy is 19.77 B.t.u.



MECHANICAL ANALOGY

The destructive effect of a blow at F is less than the whole force of the blow and less than it would be if the piston was made fast

3. A part of this is expended in pushing back the surrounding atmosphere.

4. This part, wholly or partly, is stored up as potential energy and to that extent does no mechanical work.

5. The mechanical work of damage must then be *less* than 19.77 B.t.u. (see comparison in sketch).

6. The part (3) is (nearly) $\frac{14.7 \times 144}{778}(V_2 - V_1)$, or 8.87 B.t.u.

7. The damage (5) is then (nearly) 10.9 B.t.u.

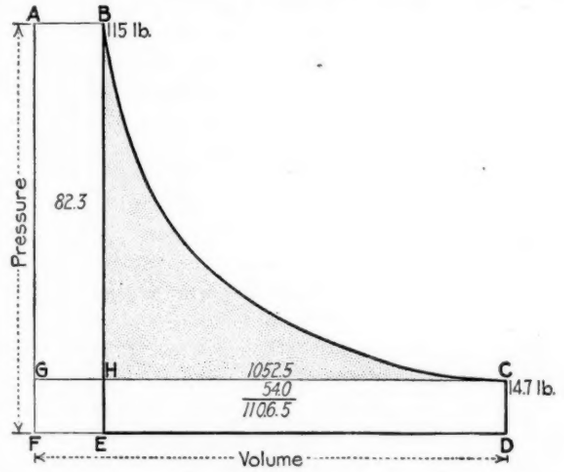
WILLIAM D. ENNIS,
Professor of Mechanical Engineering,
Brooklyn, N. Y. Polytechnic Institute.

I have read with pleasure your discussion of the problem of the boiler explosion and wish to record my vote in favor of the smaller value for the energy released per pound of hot water.

The destructive effect of a boiler explosion is due to the development of a very large volume of low-pressure steam, while some of the more spectacular phenomena are those resulting from the movement of the solid boiler itself, which often careers through the air for long distances, propelled like a rocket by the torrent of steam emitted in the opposite direction through the rent, yet this is not the main thing. Such a flying boiler, like a shot in artillery practice, may cut its way through things that may oppose its progress, but its destructiveness is limited to a narrow area. But the worst feature of a boiler explosion, particularly to the operatives of the factory, often is that it wrecks the entire building and this at such a distance from the boiler as to preclude any idea of its being caused by the direct impact of portions of the boiler itself or of solid articles converted into projectiles, therefore must be caused by the outward pressure exerted by the steam itself.

For these reasons the proper characterization of what we call a boiler explosion should really be, I think, a *building explosion*. It is the boiler that explodes first, but because the boiler is inclosed within fairly air-tight walls, the building must explode before full release of energy can be accomplished. In evidence of the force of this argument look at the record of explosions of locomotive boilers, which nearly always explode in the open so that their destructiveness is comparatively slight. The explosion of a building is the result of the sudden liberation of a large volume of low-pressure steam. A 6 x 16-ft. horizontal boiler, for instance, contains some six or seven tons of hot water, which, when released, will form, according to your figures, about an eighth of a pound of steam per pound of water. Each such eighth of a pound, at atmospheric pressure, will have a volume of some 3.2 cu.ft. And taking no account of the high-pressure steam in the steam-space, this amounts to upward of 40,000 cubic feet of low-pressure steam released instantaneously. This is equal to the cubical contents of a room 10 ft. high, 40 ft. wide and over 100 ft. long. The sudden creation of such additional room within the confines of a factory exceeds even modern American ideas of rapidity of expansion of facilities and leads to an explosion of the building.

But all this has already been recognized in the smaller value of your two columns of deadly parallel. It is represented by the portion of the shaded area of your Fig.



PRESSURE-VOLUME DIAGRAM FOR STEAM BETWEEN 115 AND 14.7 LB. ABS. (FIG. 6 OF ORIGINAL ARTICLE)

6 (here reproduced) adjacent to the line *HC*. The work represented by the area *FGCDF* below that line remains latent in the steam after the boiler explosion, and is not contributed to any external object.

SIDNEY A. REEVE,
New York City. Consulting Engineer.

THINKS THE APU WORK SHOULD BE INCLUDED

Referring to your series of three questions concerning the stored energy which is released at the time of a boiler explosion, permit me to analyze the problem a little before answering categorically.

When a pound of water is heated in confinement to a temperature of 338.1 deg. F. and a pressure of 115 lb. abs., and is then suddenly allowed to expand to atmospheric pressure, vapor will form and will continue to be formed until the mass of steam and water has been reduced to 212 deg. F. This will free an amount of energy available for doing damage, equivalent to about 10.8 B.t.u. per pound. In addition to this 10.8 B.t.u., the original pound of water will, through its expansion into steam, do work on the surrounding atmospheric envelope, in pushing it back—the *Apu* work—amounting to about 8.9 B.t.u. per pound.

The energy required to move the atmospheric envelope may be represented by $\frac{Mv^2}{2g}$ if all the available energy is used in accelerating the surrounding air, or by $M(p + \frac{v^2}{2g})$ (neglecting heat and compression effects) if the mass of the atmospheric envelope is small, and if the envelope is confined, as inside a building. From this it is evident that a part of the Apu energy is in many cases stored up as pressure in the surrounding air, to be transferred therefrom to surrounding buildings and structures and that if the pressure so attained is sufficient, part of the Apu work acts to cause damage.

Now to answer your three questions categorically:

"What is the heat equivalent, per pound, of the energy released when the pressure upon water at 338.1° F. (115 pounds absolute) is suddenly reduced to that of the atmosphere?"

About 19.7 B.t.u.

"What would be the destructive, or disturbing, effect exerted upon the envelopment by each pound of contained *water* when a boiler under 115 pounds absolute exploded?"

A maximum of about 19.7 B.t.u. is available, but the whole amount is rarely utilized as destructive effect, owing to the cushioning effect of the atmospheric envelope.

"Do you agree that the energy so exerted per pound of contained *steam* would be expressed by the difference between the internal energies at 115 lb. and at 212 degrees?"

The energy *available* would be the difference between the internal energies, as suggested in your question, but the energy *exerted* would be modified by the cushioning effect as in reply to the second question.

R. H. Danforth,
Professor, Case School of Applied Science.
Cleveland, Ohio

In this, as in most discussions, the question at issue is definition of terms, and if all parties agreed as to what the terms mean by initial clear definitions, the discussion would be entirely eliminated.

Your remarks regarding two schools of engineers and differences of opinions of engineers, etc., tends to discredit the engineering fraternity and makes it appear that different opinions are possible regarding fundamental effects.

I believe there is no such difference of opinion, but only uncertainty as to just what you mean by your questions.

S. A. Moss,
West Lynn, Mass. General Electric Co.

I have in the following arrived at the same result that you do without making use of the temperature-entropy chart. By way of variation I have used values taken from the tables by Prof. G. A. Goodenough.

The heat of the liquid, g or i', of a pound of steam at 115 lb. abs. is there given as 308.6 B.t.u.; that at 212 deg. F. as 180. The heat liberated during adiabatic expansion of a pound of water at 115 lb. abs. to 212 deg. F. is then 308.6 — 180.0 = 128.6 B.t.u. The entropy of the liquid of a pound of water at 115 lb. abs., θ or s', is 0.4870; that at 212 deg. is 0.3120. The entropy of the vapor alone, $\frac{L}{T}$ or $\frac{r}{T}$, is 1.4469 at 212 deg. F.

If x_2 is the fraction of steam that is dry after the adiabatic or isentropic expansion, we can write the equality

$$s'_{212} + x_2 \frac{r_{212}}{T_{212}} = s'_{115}$$

or

$$\theta_{212} + x_2 \frac{L_{212}}{T_{212}} = \theta_{115}$$

which on substitution becomes

$$0.3120 + x_2(1.4469) = 0.4870$$

from which

$$x_2 = 0.1209.$$

To turn a pound of water at 212 deg. F. into dry and saturated steam requires 971.7 B.t.u. We have, however, not 1 lb., but only 0.1209 lb., to be considered as dry. The heat contained by steam above the heat of the liquid —which is $(Apu + C)$ or $(Apu + I)$—is $0.1209 \times 971.7 = 117.5$. But there were liberated by the expansion of the water 128.6 B.t.u.

The difference between these two values must apparently be the energy in B.t.u. free for destructive work if adiabatic expansion really takes place. The value is 11.1.

I do not believe the value of Apu can be included in the destructive work, inasmuch as dry steam cannot be produced or steam maintained in a dry condition unless it receives or contains the total latent heat, which is intrinsic energy plus external work.

Edwin Frank.
West Philadelphia, Penn.

I have read your article with interest and profit, and think you have analyzed the problem in splendid style. However, I am of the opinion that the work of displacing the atmosphere should be included as a part of the destructive work in the case of an explosion; for if the boiler were inclosed in a building, the volume of air displaced by the generated steam would have to escape to the outside.

Another idea occurs to me, which may have something to do with the destructiveness of boiler explosions, and it is the possible rise in pressure of the air of the boiler room due to the intimate mingling of the air and hot water. I had this impressed upon me on one occasion, when I poured a small amount of hot water in a can, pressed the top on tight, and shook the can in an attempt to rinse it out. The top escaped with a violence which was impressive, to say the least.

M. W. Davidson,
Professor of Mechanical Engineering,
Vermillion, S. D. University of South Dakota.

Northern Idaho & Montana Power Co.—Elmer Dover, receiver and B. H. Grosscup, counsel, both of Tacoma, Wash., have completed plans for the reorganization of the Northern Idaho & Montaña Power Co., a $5,000,000 corporation operating gas, light, water and telephone plants in 35 cities of Oregon, Washington, Idaho and Montana. The application for a receiver was made by M. A. Morrison, of Chicago, who held a note of $30,000 against the company, and it was pointed out at the time that the company had outstanding bonds of $4,715,500, to pay the interest on which it had to borrow money. The trustees under the mortgage bond and the Oregon Power Co., which leases the Oregon plants from the parent company, also were made defendants in the suit. The receiver pointed out that the company needed $500,000 to $800,000 to make improvements and extensions, and these will be undertaken some time this summer. The creditors have agreed to a refinancing scheme and the expenditure of from $300,000 to $400,000 in improvements in the Willamette Valley of Oregon.

Locating a Blown Fuse

I had an experience a few weeks ago similar to the fuse failure described in *Power*, Mar. 20, page 392. We have a number of three-phase induction motors driving brine agitators, air compressors, conveyors and elevators.

The trouble was caused when a conveyor motor was started, which blew out one of the main fuses between the generator and switchboard. The motors continued to run, but at a somewhat reduced speed with all the lights burning dim. On going down into the engine room and testing with a light from one leg of the main circuit to another, I discovered that one phase had full voltage, while the others showed only about two-thirds.

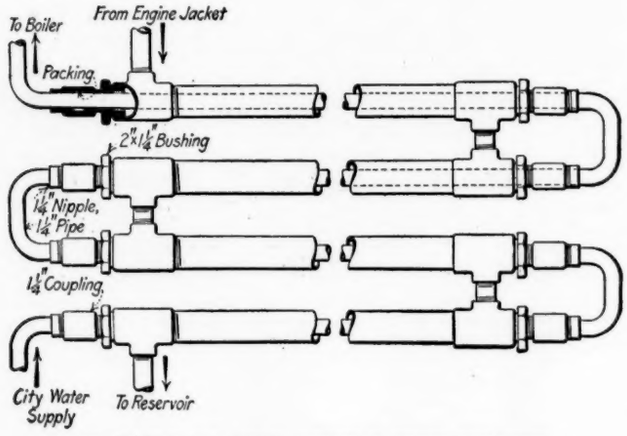
All the motors were then shut down except those on the brine agitators, which are kept running continuously. However, this was where the trouble was. The four agitator motors were feeding back on the leg where the fuse was blown, causing about two-thirds voltage to be delivered to the busbars, and from there to all the other motor and light switches in the plant. On opening the switch on the switchboard that controls the circuits to the agitator motors, all the lights went out, after which the trouble was quickly discovered, before any damage resulted. If the motors had not been disconnected, it is doubtful if the trouble would have been found so easily.

Las Vegas, Nev. J. S. FLEMMING.

Jacket Overflow Heater

In an oil-engine driven refrigerating plant it was found desirable to utilize the waste heat of the jacket water. This might have been done by installing a small pressure pump to handle the water from the jacket overflow. However, as the purity of this water was somewhat questionable, the engineer devised means by which this heat could be transferred to water already under pressure from the city mains.

Four 18-ft. lengths of 2-in. pipe were made up as shown in the illustration. Inside of these, four 20-ft. lengths of 1-in. pipe were inserted, with the ends projecting beyond the tees at the ends of the 2-in. pipe. Packing boxes were arranged by bushing the open ends of the 2-in. tees to 1¼ in. Then with a 1¼-in. close nipple, a pipe coupling and a short piece of 1¼-in. pipe threaded at one end, the packing box was complete (except for packing).



DETAILS OF THE DOUBLE-PIPE HEATER

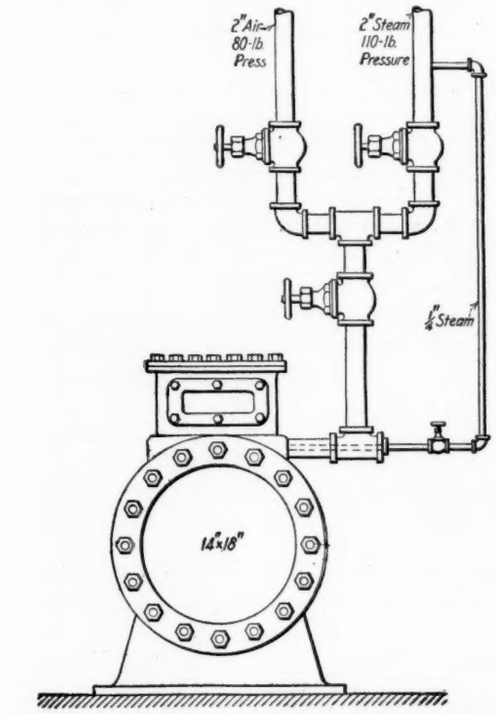
The inside pipe was then made up solid and coupled to the city-water system, and the hot water from the engine jackets was piped to circulate through the space between the two pipe surfaces and in an opposite direction to the city water flow. Ordinary valve-stem packing was used between the 1-in. pipe and the 1¼-in. coupling that served as a packing box, with the result that no leakage has occurred during the five years the apparatus has been in operation.

This double-pipe arrangement served as a feed-water heater for a 10-hp. low-pressure boiler and furnished considerable hot water for other purposes around the plant. The heat removed from the jacket water lessened the amount of work to be performed by the cooling tower and so increased the efficiency of the refrigerating plant.

Pomona, Calif. A. J. FORTNER.

How Can the Pump Exhaust Be Kept from Freezing

We have been having considerable trouble with our Cameron shaft pumps on account of ice forming in the exhaust ports when running with compressed air. I have tried running a small stream of water into the exhaust port, which helps a little. But the pumps work irregularly; that is, they frequently "hang up" for a second or two and sometimes need "hand spiking." I have also tried putting on back pressure—throttling the exhaust. But that is too wasteful. I now have a ¼-in. jet of steam tapped in, as shown, which keeps the ice out, and the pump works fine, but I would like to dispense with the steam jet if possible. I would like to hear from other readers of *Power* who may have had similar experience on this subject.



ONE WAY OF PREVENTING FREEZING—STEAM INJECTED WITH AIR

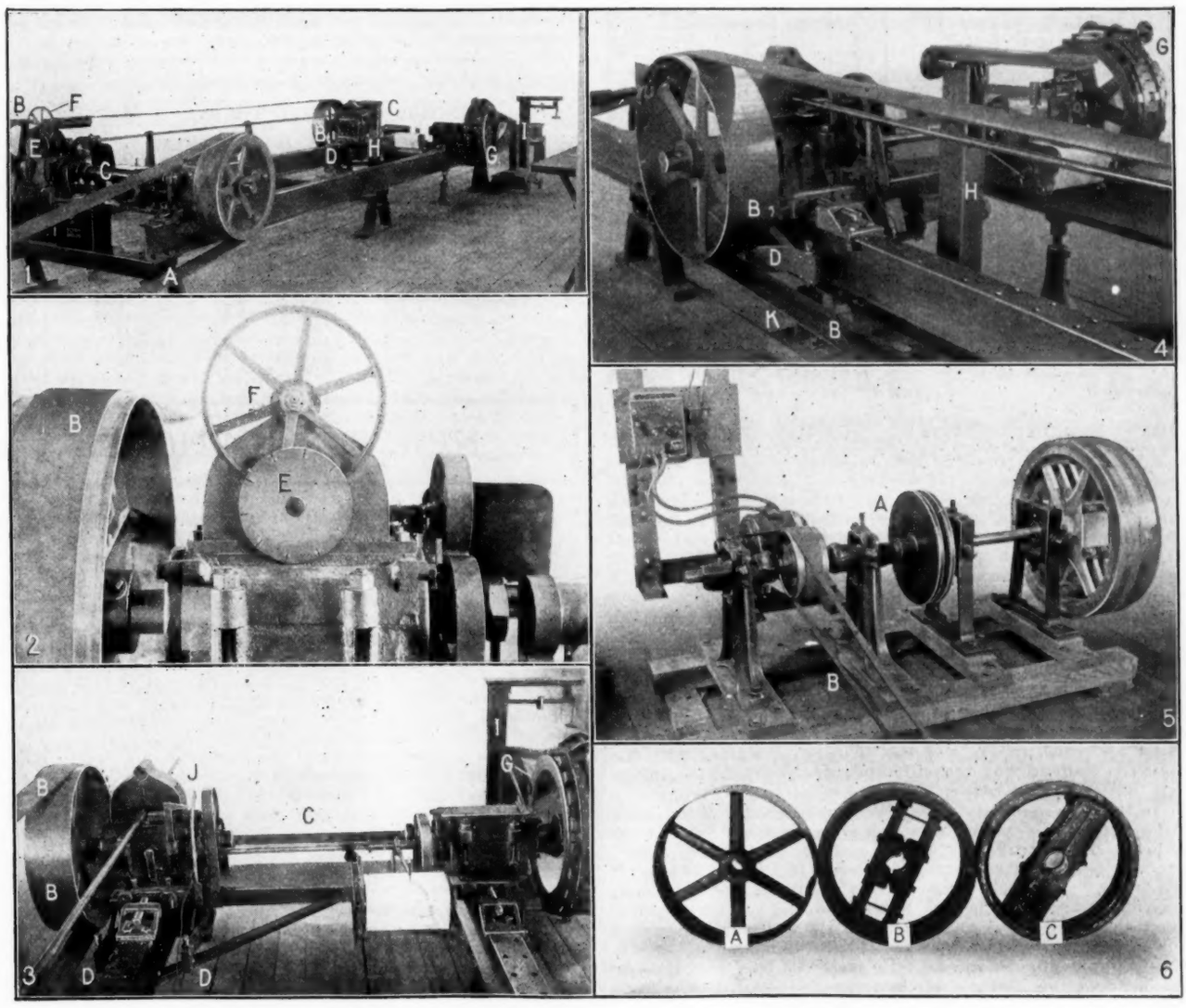
FRANK I. BERTRAND.

Crystal Falls, Mich.

Belt Slippage and Pulley Windage

SYNOPSIS—Interesting machines for belt testing and determining pulley windage. Results of tests on cast-iron and wood pulleys.

The extensive use of belting and different types of pulleys for power transmission makes desirable any information that may tend to increase the efficiency or dependability of belt drives. In this connection an interesting paper was presented at the recent meeting of the Indiana Engineering Society by L. V. Ludy, professor of experimental engineering at Purdue University. In the paper, reports were made of certain tests to determine belt slippage and the effect of pulley windage, and a description of the mechanism employed was given.



FIGS. 1 TO 6. DETAILS OF BELT-TESTING MACHINE

Fig. 1—Purdue belt-testing machine. Fig. 2—Indicating and recording belt-slip meters. Fig. 3—Torsional dynamometer spring and two belt-tension levers. Fig. 4—Method for determining belt tension. Fig. 5—Pulley-windage testing machine. Fig. 6—Pulleys used in windage tests

The tests were conducted on the Purdue belt-testing machine, which was developed by members of the instructional corps of the School of Mechanical Engineering and constructed in the university shops in 1915. It contains a number of features indicated in the general view, Fig. 1. The mechanism is made up of the following essential elements: The belt A, which transmits power from an electric motor; the belt and pulleys B, which are being tested; the transmitting and receiving dynamometer torsional springs CC; the belt-tension weighing device D; the belt-slip indicator E; the belt-slip recorder F; the prony absorption brake G; the platform scales H for weighing the belt tension received from the belt-tension device D; and the platform scales I for determining the brake load being carried. Both torsional dynamometer springs are fitted with suitable recording devices which keep an accurate record of the torque being carried. The record sheet is shown in Fig. 3. The shafts to which the ends of the torsional dynamometer springs are connected are fitted with annular ball bearings. To both the transmitting and receiving heads are fitted revolution counters, which are simultaneously thrown in and out of gear at the will of the operator by an electric current furnished by a storage battery. This equipment is not clearly shown.

Fig. 2 shows more in detail the belt-slip indicator E. The circular disk contains 100 graduations on its outer edge, each of which represents a belt slip of one revolution. The pointer shown near the graduation 10, near the rim of the gear wheel F, is carried at the end of an arm which is driven by the mechanism at the receiving head. While in operation no slip is indicated when both the disk and pointer travel together. When slip is shown, there will be a relative movement between the disk and the pointer, the amount being represented by the difference in the two readings. The large gear in the foreground drives the belt-slip recorder F, which is fitted with a sheet of paper on which a pencil records the amount of slip.

A good illustration of the torsional dynamometer spring C is shown in Fig. 3. The spring is flat, being about ¼ in. thick, 2 in. wide and 30 in. long. The figure also shows the character of the torque record secured. The receiving head shown is

capable of adjustment to suit the belt tension being carried. The pointer J is used to indicate the proper position for the parts of the tension-weighing device DD. In taking this view the platform scales H used for weighing the belt tension had been removed.

The design of the belt-tension weighing device D is more clearly illustrated in Fig. 4. It consists of two levers, located on either side of the frame of the machine, the proportions being such as to permit the sum of the two belt tensions to be read directly on the scales H. The two belt-tension levers are connected by the equalizing lever K, which rests on the platform of the scales. The machine is fitted with many refinements not referred to, which make it extremely useful in this work.

The tests under consideration were all conducted on a single-ply oak-tanned leather belt, having an average width of 3.96 in. and a thickness of 0.194 in., representing a mean

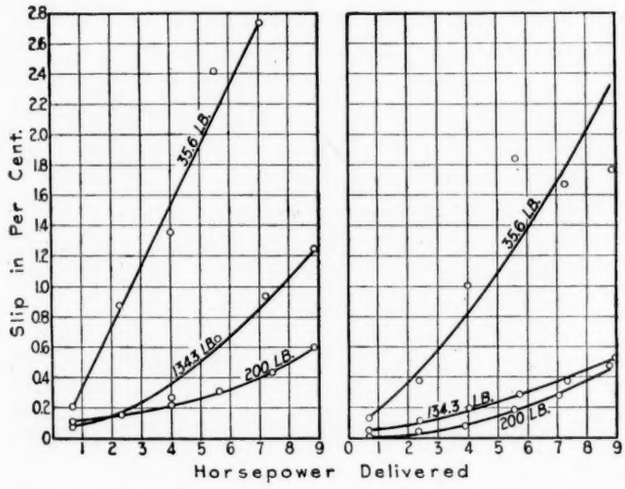


FIG. 7. RESULTS OBTAINED WITH CAST-IRON PULLEYS

FIG. 8. RESULTS OBTAINED WITH WOOD PULLEYS

cross-sectional area of 0.76 sq.in. Two series of tests were conducted, the first using cast-iron pulleys and the second, wood pulleys. The nominal dimensions of all pulleys were 24-in. diameter and 6-in. face, all having a slight crown. A belt speed of approximately 2800 ft. per min. was maintained throughout. The initial belt tensions used in both series of tests were 200, 134.3 and 35.6 lb. per sq.in. of cross-section. The speed ranged from 430 to 450 r.p.m. The results are presented graphically in Figs. 7 and 8 respectively.

Reference to the curves shows that under all conditions the slip increased with an increase of horsepower transmitted for both the wood and cast-iron pulleys and that the slip decreased as the initial belt tension increased. The slip when using the wood pulleys was less than that obtained with the cast-iron pulleys, but the difference decreased as the initial belt tension was increased.

In the windage tests experiments were conducted on three different pulleys having the same nominal dimensions, as follows: Diameter, 24 in.; width of face, 6 in. The pulley-windage testing machine used is shown in Fig. 5. Briefly, it consists of two shafts fitted with self-aligning annular ball bearings, each shaft having a circular disk attached at its inner end, as at A. A variable-speed electric motor furnishes power to the shaft on the left side in the manner shown. When the motor is started, the shaft on the left rotates, causing rotation of the shaft on the right, through the medium of a delicate flat spring connecting the two disks. The outer end of the spring can be seen projecting beyond the outer edges of the disks. Suitably arranged stops limit the relative movement of the two disks. By an ingenious device the relative movement of the disks causes a pointer to move radially along a graduated scale, not shown in the figure, by means of which the driving torque can be accurately determined. The small belt B was used to drive a tachometer.

Having first calibrated the machine, the process of testing a pulley for windage consisted briefly in attaching the pulley to the driving shaft of the machine, as indicated in Fig. 5, and driving it at an observed speed, noting the reading of the dynamometer spring scale. In attaching the pulley, care must be exercised to insure its running true and with as little vibration as possible. Knowing the dynamometer spring-scale reading for a pulley being driven at a given speed, the windage horsepower can be taken off calibration curves previously determined.

The pulleys tested are designated in Fig. 6 as A, B and C. The first-named is the usual form of cast-iron pulley, and B and C are two different types of wood pulley. The results obtained from the tests are given in the accompanying table. Perhaps the most interesting figures in the table are found in the column on the extreme right. These cost data are computed on a basis of $50 per horsepower-year, this figure being taken for convenience only. It is too great for a large modern power plant, but it is not far from correct for a small plant fitted with noncondensing engines of, say, 100-hp. capacity. The data show that the cast-iron pulley A is more economical to operate than either of the wood pulleys. At the maximum speed recorded the cast-iron pulley absorbs about 40 per cent. of the power required for the wood pulley B. At the lowest speed little differences in the windage horsepower of all pulleys were obtained. For all of the pulleys tested, the operating cost per year on the basis stated, for all speeds, varies between the limits of $0.20 and $2.20.

The question of the power required to drive a pulley is in itself a small matter, but when the great number of pulleys used in some of the large manufacturing plants is considered, then the question of windage becomes worthy of consideration if economy and efficiency are sought for.

WINDAGE TESTS OF THREE BELT PULLEYS

Designation of Pulley	Weight of Pulley, Lb.	Weight of Pulley, Oz.	Speed, R.p.m.	Approx. Per. Speed, Ft. per Min.	Dynamometer Scale Reading, In.	Windage Horsepower	Operating Cost, $50 per Hp.-Year
A	71	7	232	1,457	0.18	0.0042	$0.21
			323	2,028	0.20	0.0048	0.24
			417	2,619	0.27	0.0078	0.39
			508	3,190	0.51	0.0192	0.96
B	30	3	232	1,457	0.19	0.0046	0.23
			323	2,028	0.34	0.0120	0.60
			417	2,619	0.68	0.02585	1.29
			508	3,190	1.19	0.0443	2.22
C	29	1	232	1,457	0.17	0.00345	0.17
			323	2,028	0.22	0.0058	0.29
			417	2,619	0.39	0.01535	0.77
			508	3,190	0.75	0.02745	1.37

NEW PUBLICATIONS

EXPORT TRADE DIRECTORY. Published by the "American Exporter," 17 Battery Place, New York. 1917. Cloth; 6x8½ in.; 536 pages. Price, $5.

This handbook has been considerably enlarged. It contains 536 pages against the 369 pages in the former edition, and instead of only 785 New York export merchants listed, there are now given 1295. There are 117 San Francisco exporters listed, and in addition to this there are lists covering Boston, Philadelphia, Chicago, New Orleans, Portland, Ore., Seattle, Tacoma, and other cities, making a grand total of 1562 American concerns engaged professionally as export merchants or commission houses. The directory also contains important lists of 85 New York banks dealing in foreign exchange and 49 such banks in other cities in the United States. Fifty-four foreign freight forwarding offices in various cities outside of New York are mentioned and 136 such offices in the city itself. There are listed 115 steamship lines plying from New York, and in addition 25 concerns maintaining occasional sailings. In the 1915 edition there were 128 combination export agents listed; in this edition the number is 150. Another important feature is the 37 pages of classified indexes listing the export merchants according to the particular goods they ship. These indexes include the complete names and addresses of the firms. A revised uptodate map of the export district of New York City is given, which makes it easy for out-of-town manufacturers to find their way directly to any desired location in lower New York where exporters mostly congregate.

WEATHERING OF COAL. By J. B. Porter. Canada Department of Mines, Canada. Paper; 194 pages; 6¼ x 9¾ in.; tables and illustrations.

This is an extra volume, supplementing Report No. 83. It is a contribution to the general investigation that is being carried on through the world and is a general statement of what is now known on the subject of weathering of coal. A considerable part of the present work is a review of the most important papers that have been published on the subject. The author has presented this matter in logical sequence and has aimed to state the views of the several writers as fairly as possible, commenting and criticizing where either seemed desirable. The volume also deals with the individual experimental work of the author and his associates. It is highly special and concerns only a few points in a very complex matter. Among the subjects treated is a general discussion

of weathering of coal, followed by a discussion of the causes of weathering. Then comes the question of oxidation of coal at ordinary temperatures and at elevated temperatures. Next the subject of the prevention of fire in stored coal is discussed, and the last chapter deals with the effect of slow weathering on the calorific value of coal, with special reference to certain Canadian cretaceous coals. More than 60 tables are presented, and there are 65 illustrations. Much valuable information has been compiled, and the volume will be of value to those who are interested in the subjects of which it treats.

ENGINEERING AFFAIRS

The Chicago Engineers' Club has under consideration a proposition for an engineers' building to house all the engineering societies in Chicago. Nine of the eleven societies approached responded favorably, the inference being that, were a definite and practical scheme evolved by the Chicago Engineers' Club, the opportunity for negotiating for space would be welcomed, either by building an addition to the present quarters or by going to an entirely new site.

Tacony Association No. 9, N. A. S. E., held its sixteenth anniversary on Apr. 19, at Masonic Hall, Frankford, Penn. Upwards of 250 engineers and guests were in attendance. At nine o'clock the company took seats in the large ballroom, where an appetizing menu was served. During the dinner an entertainment was furnished by Charles A. Hayes and Miss Fulmer, Engineering Supply Co., the Musical Ogdens, Tacony Association, and James McKay, George W. Lord Co. After the coffee Jack Armour, of "Power," told stories and recited. Dancing followed. Fred M. Gazier was the toastmaster.

Phœnix Association, No. 24, N. A. S. E., of New York City, held its annual dinner and dance at the Hotel Netherland, on Mar. 15. The festivities began at 8:30 with dancing, and at 10:30 the company was conducted to the main dining room, where covers were laid for over two hundred. An entertaining program of songs was enjoyed between the courses. At the close of the dinner, dancing was again indulged in. The success of the dinner was due to the efforts of John E. Elder, F. G. Jolley, John C. Stewart, W. M. Brainard and George E. Whittemore, who comprised the committee of arrangements.

Massasoit Association No. 2, N. A. S. E., of Springfield, Mass., held its fifteenth annual banquet on Apr. 21, at the Highland Hotel. There were about 200 present. Herbert H. Stone, past national president, was the toastmaster, and introduced the following speakers who made brief addresses: Mayor Frank E. Stacy, Past National Presidents William Reynolds and Walter H. Damon, President John Quinn, Vice President Joseph Eccleston and J. H. Henderson, secretary of the New England States Association; James Markham, state deputy; and F. S. Eggleston, Jr., president of the Commercial Engineers' Association. During the evening the diners were entertained by Herbert Self, Norman Dash, Dennis Hogan, Joe McKenna and Jack Armour. Coates' orchestra furnished the music. E. L. Deane, E. J. Auger and L. W. Kellogg comprised the banquet committee.

New Haven Section A. S. M. E.—The spring meeting of the New Haven Section of the American Society of Mechanical Engineers was held at Mason Laboratory, Yale University, on the afternoon and evening of Apr. 19. At the afternoon session Herbert C. Nickerson, Chief Engineer of Pumping Stations, New Haven Water Co., gave a history of the equipment of this company, representing the development in waterworks practice during the past forty years. After listening to the paper those in attendance were taken in automobiles on an inspection trip to the stations of the company, returning for dinner at the Yale Dining Club. At the evening session two illustrated papers were presented, one on "The Development of the Centrifugal Pump" by F. F. Nickel, of the Henry R. Worthington Co., and "Pumping Machinery for Industrial Purposes" by H. M. Chase, of the Deane Works, Holyoke, Mass. These papers discussed the different types of centrifugal and direct-acting pumps, their characteristics and applications.

Philadelphia Section, A. S. M. E.—On Tuesday evening, Apr. 24, Robert Yarnall, of the Yarnall-Waring Co., read a paper before the Philadelphia Section of the American Society of Mechanical Engineers at the Engineers' Club on "Recent Developments in V-Notch Weir Measurement." The paper described the various methods in use for translating the head in such a weir into an expression of the quantity flowing and forms of weir designed to make the flow vary in direct proportion to the head in much the same way as the article on pages 582 et seq. of this issue, and then took up in detail the Lea meter as adapted and developed by the author's company to meet American conditions. A number of slides were thrown on the screen and parts of the meter exhibited. The paper was discussed by Messrs. Ledoux, Bigelow, McBride and Moody, but the informal discussion at the following collation among the representatives of the various types of meter present was not the least interesting feature of the gathering.

Iron and Steel Electrical Engineers—The Pittsburgh Section of the Association of Iron and Steel Electrical Engineers held its regular monthly meeting at the Fort Pitt Hotel, Pittsburgh, Penn., Saturday, Apr. 21, 1917. Papers on standardization were presented by members of the Standardization Committee. It was pointed out that application must precede standardization, and as it is practicable to standardize only so far as these standards will be adopted by all the operating companies, the following factors in control application should be taken into consideration as a basis for making standards for the operating engineer: (1) Disconnecting means; (2) overload protection; (3) service, classification or duty; (4) safety requirements; (5) power supply; (6) system of inspection and maintenance. The logical way to start standardization is to standardize a common language by means of which all interested persons can refer to control apparatus without ambiguity. This means standardizing definitions, terms, symbols, wiring diagrams, etc.

MISCELLANEOUS NEWS

Reduction in Electricity Rates in Portland, Ore.—Anticipating an order from the Oregon Public Service Commission, the Portland Railway, Light and Power Co. is preparing for a cut in its rates in Portland and vicinity that will average 16 per cent. on residence, commercial and power service. The company expects that the order will be made to become effective May 1, so that the first reductions will appear on the bills submitted to the customers by the company on June 1. The commission has practically completed its valuations of the Portland Railway, Light and Power Co. properties and has cut off about $9,000,000 of the valuation claimed by the company.

Refund in the Philadelphia Rate Case—To pay the expense of the valuation and rate case and a refund to the City of Philadelphia on its street-lighting contract for 1915, the Philadelphia Electric Co. has made a deduction of $481,102 from its surplus for the year 1916. The gross earnings of the company for the year 1916 were $10,260,072, an increase of $1,482,148 over those of 1915; the net income was $2,794,051, against $2,414,551 for 1915. The total connected commercial load on Dec. 31, 1916, was 233,756 kw., an increase over the previous year of 37,830 kw., and the connected railway load increased 1200 kw. over that of 1915, making it 33,450 kw. Dec. 31, 1916. J. B. McCall, president of the company, called attention in his annual report to the fact that if it had not been for the unusually large increase in the gross earnings, it would have been necessary to reduce the dividends on account of the reduction in rates, which benefited principally the small customer.

Reduction of Electric Rates in Borough of Queens—Beginning May 1, the Queens Electric Light and Power Co., Borough of Queens, New York City, will voluntarily reduce its rates for electric current from a maximum of 12c. to 9c. per kw.-hr. The reduction affects the entire Borough of Queens except the Rockaway section. The new rates will mean a yearly saving of approximately $100,000 to the public. The company also agreed that if business conditions warranted, it would further reduce its rate to 8.5c. per kw.-hr., with a minimum charge of 60c. for each meter instead of $1. In November, 1916, the Public Service Commission began an investigation into the reasonableness of the company's rates.

It is specifically set forth by the commission that no customer's bills shall be increased by the new rate. Every customer shall receive at least a decrease in the present rates equivalent to a reduction from 12c. per kw.-hr. with $1 minimum charge to 11c. per kw.-hr. with $1 minimum charge.

In the opinion rendered by Commissioner Whitney, it is pointed out that the superficial criticism made against the present as well as the new rates of the company is that they are higher than those in the Boroughs of Manhattan and Brooklyn. However, this comparison does not afford a just basis for determining the reasonableness of the rates on account of the dissimilarity in the conditions under which the different electric companies operate in the several boroughs. Although the territory served by the New York & Queens Electric Light and Power Co. is equal to the combined territories of the Boroughs of Manhattan, Brooklyn and the Bronx, it has less than one-tenth of the population. Queens is still largely a rural region with many portions sparsely settled.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago
Buckwheat	$3.40@4.40	$3.05@3.20	$6.50@6.75	$3 25@3 50
Rice	.....	2.50@2.65	5 50@5.75	2.70@2.95
Boiler	.....	.....	4.25@4.50	.....
Barley	2.65@3.65	2.20@2.35	4.15@4.40	2.35@2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago
Clearfields	$4.25@4.50	$1 40@1.90	$9.50@10.00	$4.25@5.00
Cambrias and Somersets	4.75@5.50	1.60@2.10	9.75@10.50	4.60@5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $5.50@5.75, as compared with $2.75@2.85 a year ago; on cars Boston price is $11@11.25.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago
Buckwheat	$3.70@3.80	$2.75	$5.25@5.50	$3.00@3.25
Rice	3.00@3.30	2.25	4.50@4 75	2.15@2.25
Barley	2.50@2.80	1.75	3.50@3.75	2.00@2.10

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$6.25@6.50	$6.25@6.50	$4.50@4.75
South Forks	6.50@6.75	.....	4.75@5.00
Nanty Glo	6.50@6.75	.....	4.75@5.00
Somerset	6.25@6.50	6.25@6.50	4 50@4.75
Quemahoning	6.50@6.75	6.50@6.75	4.75@5.00

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago
Buckwheat	$2.50	$1.55	$3 40	$2.30
Rice	2.00	.90	3.00	1 80
Boiler	1.80	....	2.90	....
Barley	1.50	.55	1.75	1 30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Apr. 28, 1917	One Year Ago
Slack	$3.25@3.50	$1.05@1.15
Mine-run	3.25@3.50	1.20@1.30
¾-in.	3.25@3.50	1.30@1.40

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$2.75@3.25	$2.75@3 00	$4.00@4 50	$2.00@2.25	$2 50@2.75
Lump	3.00@3.25	3.00@3.25	4.00@4.50	2 50@2.75	2.75@3 00
Egg	3.00@3 25	3.00@3.25	4.00@4 50	2.50@2.75	2 75@3.00
Nut	3.00@3.25	3.00@3.25	.....	2.50@2.75	.....
No. 1 nut	3.00@3.25	.....	.....	2.50@2.75	.....
No. 2 nut	3 00@3.25	.....	.....	.....	.....
No. 3 nut	2.75@3.00	.....	.....	.....	.....
No. 1 washed	3 00@3.25	.....	.....	.....	.....
No. 2 washed	3.00@3.25	.....	.....	.....	.....
Mine-run	2.50@2.75	2 50@2.75	4.00@4 25	2.00@22.5	2.25@2 75
Screenings	2.25@2.75	2.50@2.75	.....	1 75@2.25	2.25@2.50

Hocking lump, $3.50@3.75; splint lump, $3.50@3 75.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago	Apr. 28, 1917	One Year Ago
6-in. lump	$3.00@3.25	$1.35@1.45	$2.00	$1.25@1 40	$1.75	$1.10
2-in. lump	3 00	1.20@1.35	2.00	1.15@1.25	1 60	.90
Steam egg	3 00	1.20@1.35	2.00	1.15@1.25	1.60	.90
Mine-run	2 75	1 05@1.20	1.75	1.05@1.15	1 60	.90
No. 1 nut	3.00	1.20@1.45	2.00	1.15@1 25	1.75	.90
2-in. screen	2.50	.90@1.10	1.75	.85@1 00	1.65	.95
No. 5 washed	2.50	.90@1.10	1.75	.85@1.00	1.60	.90

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$3 25@3.50	Carbon Hill	$2.75@3.00
Big Seam	2.75@3.00	Cahaba	3.25@3.50
Black Creek	3.25@3 50		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Birmingham—City Council will construct and equip a municipal electric-light and power plant, for which $500,000 bonds were voted. J. Kendrick, City Engr.

Ariz., Kingman—The Chloride X-Ray Mining Co. will install an electric plant at its mine, involving 100-hp. engine and 5 drill compressors.

Ariz., Wickenburg—City voted $12,000 bonds to install an electric-light and power plant.

Calif., Alhambra—The Pacific Electric Railway Co., controlled by the Southern Pacific Co., Pacific Electric Bldg., Los Angeles, plans new substation. J. McMillan, Los Angeles, Gen. Mgr.

Idaho, Drummond—City plans election to vote on bonds to install an electric-light plant.

Ill., Chicago—The Central Manufacturing District, c/o J. A. Spoor and A. G. Leonard, 38 South Dearborn St., has had plans prepared for a power house. R. L. Vaniman, c/o United States Yards and Transit Co., Mechanical Engr.

Ill., Rock Island—G. W. Burr, Commandant, is having plans prepared for a central heating plant for the Rock Island Arsenal. Estimated cost, $150,000.

Ind., Brazil—The Crawford-McCrimmon Co. will construct an addition to its plant.

Iowa, Des Moines—The Des Moines Electric Co., 8th and Locust Sts., is having plans prepared for a central heating plant. H. J. Vance, Pur. Agt.

Kan., Agra—City voted $8000 bonds to install an electric-lighting system.

Kan., Caney—The Caney Electric Light and Railway Co. will rebuild its plant which was recently damaged by fire.

Kan., Irving—City voted $7000 bonds to build a transmission line from Irving to Blue Rapids and a distributing system and lighting system in the city limits.

Kan., Quinter—City voted $14,000 bonds to install an electric-lighting system.

Kan., Toronto—City voted $15,000 bonds to install an electric-light system.

La., Oak Grove—City is considering plans for an electric-light plant.

Minn., Lancaster—City plans to hold an election to vote on $8000 bonds to install an electric-lighting system. B. Abbott, Ch. Engr.

Mo., Boonville—The Kemper Military School is having plans prepared for improvements to its power house, including additional boilers and generation.

Mo., Kirksville—City will vote May 4 on bonds to install an electric-light plant.

Mo., St. Joseph—City plans to hold an election to vote on $172,000 bonds to extend and improve the electric-light plant.

Mo., Springfield—City Council plans to hold an election to vote on $40,000 bonds to establish an electric-light plant. S. R. Fisher, City Engr.

Ohio, Alliance—The Alliance Gas and Power Co. will increase its capital stock from $550,000 to $1,550,000 and will improve its plant and lines. W. J. Rose, Gen. Mgr.

Ohio, Xenia—(Official)—The Ohio Soldiers' and Sailors' Orphan Home will install a new low-pressure steam-heating system. Estimated cost, $35,000. A. C. Elder, Ch. Engr.

Okla., Ardmore—J. A. Cosner will construct a hydro-electric plant, including a dam across the Washita River, to develop 2500 hp. and irrigate 40,000 acres. J. W. Maxey, Houston, Engr.

Okla., Grandfield—Maple & Green are considering plans for rebuilding their electric plant.

Okla., Norman—The Oklahoma Gas and Electric Co. will extend its transmission line from Oklahoma City to Norman.

Ont., Ft. Erie—City Council plans to install an electric-light plant.

Penn., Harrisburg—The Harrisburg Railways Co., 12 South Market St., is having surveys made by B. J. Arnold, Chicago, for extensions and improvements to its power plant.

Penn., Kutztown—City plans to install an electric-light plant. Estimated cost, $25,000.

Penn., Lemoyne—The United Electric Co. will construct an addition to its plant and install a new turbine, rotary converter and transformer equipment. Estimated cost, $125,000. A. S. Bentz, Ch. Engr.

Penn., Wernersville—Berkshire Electric Co. has applied to the Public Service Comn. for permission to issue $45,000 bonds to extend and improve its system. S. Redsecker, Supt.

S. C., Central—City voted bonds to install an electric-lighting system. S. D. Brown, Toccoa, Ga., Engr.

S. D., Mobridge—Ferris Bros. purchased the electric-light plant owned by B. S. Hill and will construct a new plant. Estimated cost, $75,000.

Tex., Celina—City will rebuild its electric-light and power station which was recently destroyed by fire.

Tex., Donna—Donna Light and Power Co., recently incorporated with $5000 capital stock, will install an electric-light and power plant.

Tex., Hamlin—The Hamlin Light, Power and Ice Co., recently incorporated with $60,000 capital stock, will construct an electric-light and power plant. A. V. Wainwright, stockholder.

Wash., Palouse—The Washington Water Power Co. will rebuild its power plant under terms of a 25-year franchise passed by the City Council.

Wis., Embarrass—City is having plans prepared for a hydro-electric plant.

Prices—Materials and Supplies

ELECTRICAL SUPPLIES

Knife Switches—Following are net prices each in cities named for knife switches mounted on slate base, front connected, punched clip type 250 volts:

	30 Amp.				60 Amp.			
	New York	Chicago	St. Louis	Dallas	New York	Chicago	St. Louis	Dallas
D. P. S. T., fuseless.	$0.91	$0.58	$0.49	$0.68	$1.04	$1.04	$0.88	$1.22
D. P. S. T., fused....	.91	.90	.76	1.06	1.53	1.53	1.30	1.80
D. P. D. T., fuseless.	1.45	.99	.84	1.16	1.70	1.70	1.44	2.00
D. P. D. T., fused....	1.87	1.91	1 58	2.20	2.89	2.89	2.45	3.40
T. P. S. T., fuseless.	1.36	.87	1.15	1.02	1.57	1.57	1.32	1.84
T. P. S. T., fused....	1.36	1.36	1.15	1.60	2.30	2.30	1 94	2.70
T. P. D. T., fuseless.	2.27	1.53	1.92	1.80	2.64	2.64	2.23	3.10
T. P. D. T., fused....	3.10	2.99	2.53	3.52	4.63	4.63	3.92	5.44

	100 Amp.				200 Amp.			
	New York	Chicago	St. Louis	Dallas	New York	Chicago	St. Louis	Dallas
D. P. S. T., fuseless.	$2.13	$2.13	$1.80	$2.50	$3.83	$3.83	$3.24	$4.50
D. P. S. T., fused....	3.12	3.11	2.64	3.66	5.75	5.75	4.87	6 76
D. P. D. T., fuseless.	3.83	3.83	3.24	4.50	6.38	6.38	5.40	7.50
D. P. D. T., fused....	6.29	6.29	5.33	7.40	11.05	11.05	9.36	11.70
T. P. S. T., fuseless.	3.20	3.20	2.71	3.76	5.75	5.75	4.87	6.76
T. P. S. T., fused....	4.68	4.68	3.96	5.50	8.62	8.62	7.30	9.13
T. P. D. T., fuseless.	5.87	5.87	4.97	6.90	9.86	9.86	8.35	10.44
T. P. D. T., fused...	10.07	10.07	8.52	10.66	17.68	17.68	14.98	18.72

Lots $25 and more, list.

Fuses—Following are net prices of inclosed fuses each, in standard packages, in cities named:

	New York	Chicago	St. Louis	Dallas	Package
30	$0.13	$0.18	$0.09	$0.13	100
31-60	.18	.25	.12	.18	100
61-100	.46	.43	.32	.46	50
110-200	1.02	.70	.70	1.02	25
225-400	1.84	1.17	1.26	1.84	25

FUSE PLUGS, PER 100

	New York	Chicago	St. Louis
30	$4.20	$6.50	$3.90

Standard package fuse plugs, 500; 100, less than package, 5c. each.

Sockets—Following are net prices in cents each in standard packages in cities named:

	⅛-In. Cap				⅜-In. Cap			
	Package	Key	Keyless	Pull Chain	Package	Key	Keyless	Pull Chain
New York	500	23.10	21.00	42.00	250	27.30	25.20	46.20
Chicago	500	31.50	28.50	57.00	250	37.00	39.00	62.50
St. Louis	500	21.78	19.80	39.60	250	25.74	23.76	43.56
Dallas	500	23.76	21.60	43.20	250	28.08	25.92	47.52

	Pendant Cap ⅛ In.				Less Than Package in ⅛ and More Than Package in Pendant and 25 Each		
	Package	Key	Keyless	Pull Chain	Key	Keyless	Pull Chain
New York	250	23.10	21.00	42.00	27.00	24.00	48.00
Chicago	250	31.50	31.50	57.00	35.00	31.00	44.00
St. Louis	250	21.78	19.80	39.60	26.40	24.00	48.00
Dallas	250	23.76	25.50	43.20	28.05	25.50	40.51

Cut Outs—Following are net prices each in cities named for standard package quantities:

EDISON PLUG 0-30

	Package	New York	Package	Chicago	St. Louis
D. P. M. L.	50	$0.18	150	$0.24	$0.17
T. P. M. L.	50	.26	100	.35	.24
D. P. S. B.	50	.19	100	.26	.18
T. P. S. B.	50	.32	75	.50	.30
D. P. D. B.	25	.37	100	.50	.34
T. P. D. B.	25	.54	50	.72	.50
3- to 2-wire D. B.	25	.38	100	.51	.35

CARTRIDGE FUSE

	0-30			31-60			61-100		
	New York	Chicago	St. Louis	New York	Chicago	St. Louis	New York	Chicago	St. Louis
D. P. M. L.	$0.33	$0.40	$0.30	$0.84	$1.01	$0.77	$1.68	$2.02	$1.48
T. P. M. L.	.48	.58	.44	1.20	1.44	1.10	2.40	2.88	2.21
D. P. S. B.	.42	.51	.39	1.05	1.26	.96	...	...	...
T. P. S. B.	.81	.97	.74	1.80	2.16	1.65	...	...	...
D. P. D. B.	.78	.94	.72	2.10	2.52	1.93	...	...	...
T. P. D. B.	1.35	1.62	1.24	3.60	4.32	3.30	...	...	...
3- to 2-wire D. B.	.90	1.08	.83	2.52	3.03	2.31	...	...	...

Separable Attachment Plugs—Following are prices each in cities named:

	Package	Porcelain	Composition	Package	Side Outlet Current Taps
New York	250	$0.21	$0.28	50	$0.35
Chicago	450	.27	.36	50	.45
St. Louis	250	.16	.17	50	.33

Cord—Following are prices each in cities named, in cents per foot:

	Coil, Foot	New York	Chicago	St. Louis
No. 18 cotton, parallel	250	2.83	4.29	2.65
No. 16 cotton, parallel	250	3.65	5.85	3.36
No. 18 cotton, reinforced	250	4.07	4.47	3.05
No. 16 cotton, reinforced	250	4.86	5.55	4.22
No. 18 canvasite	250	3.17	3.58	4.00
No. 16 canvasite	250	3.88	4.45	4.98

	Coil, Foot	New York	Chicago	St. Louis
¼-in. loom	250	3.00	3.00	2.20
⅜-in. loom	250	4 50	4.50	3 96
½-in. loom	200	6.00	6.00	5.28
⅝-in. loom	200	7.50	7.50	6.06
¾-in. loom	150	9.00	9.00	7.92
1-in. loom	100	12.50	12.50	11.00
1¼-in. loom	100	16.50	16.50	14.52
1½-in. loom	100	20.00	20.00	17.60

Copper Wire—Following are prices in cents per foot in cities named for rubber-covered wire in standard quantities of 1000 ft.:

	New York			Cleveland		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	13.50	14.36	26.00	11.50	14.00	33.00
12	17.70	19.32	38.04	17.00	18.00	38.20
10	24.30	26.76	53.04	....	....	....
8	34.50	37.28	74.16	....	....	....
6	61.24	64.84	....	....	....	....
5	72.72	76.72	....	....	....	....
4	78.96	92.64	....	....	....	....
3	107.20	112.00	....	....	....	....
2	131.60	136.80	....	....	....	....
1	171.20	178.00	....	....	....	....
0	215.00	215.60	....	224.00	224.00	224.00
00	264.00	264.00	....	273.60	273.60	273.60
000	325.20	325.20	....	336.00	336.00	336.00
0000	396.80	396.80	....	408.80	408.80	408.80

	Chicago			St. Louis		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	14.00	16.00	28.00	12.00	16.50	29.00
12	25.62	29.22	58.59	25.74	29.34	52.96
10	32.61	36.46	66.50	33.44	37.29	67.20
8	47.25	51.65	93.40	47.68	52.08	94.20
6	68.50	73.00	....	77.80	82 30	148.14
5	82.50	87.50	....	92.45	97.45	175.41
4	99.60	105.10	....	101.02	105.97	201.36
3	115.65	120.95	....	122.85	128.25	....
2	136.35	142.20	....	150.75	156.60	....
1	178.20	185.80	....	195.75	203.40	....
0	244.35	244.35	....	234.27	234.47	....
00	301.95	301.95	....	288.13	288.13	....
000	368.10	368.10	....	353.97	353.97	....
0000	449.55	449.55	....	432.20	432.20	....

Conduit, Elbows and Couplings—Following are New York net prices per 1000 ft. for conduit and per unit for elbows and couplings:

	Conduit		Elbows		Couplings	
	Enameled	Galvanized	Enameled	Galvanized	Enameled	Galvanized
½-in.	$61.20	$66.30	$0.1482	$0.1596	$0.0546	$0.0588
¾-in.	80 50	87.40	.195	.21	.078	.084
1-in.	119 00	129.20	.2886	.3108	.1014	.1092
1¼-in.	161.00	174.80	.3735	.4005	.1411	.1513
1½-in.	192.50	209.00	.498	.534	.1743	.1869
2-in.	259.00	281.20	.913	.979	.2324	.2492
2½-in.	409 50	444.60	1.494	1.602	.332	.356
3-in.	535.50	581.40	3.984	4.272	.498	.534
3½-in.	671.60	726.80	8.798	9.434	.664	.712
4-in.	817.50	882.90	10.168	10 902	.83	.89

Standard lengths rigid, 10 ft. Standard lengths flexible, ½ in., 100 ft. Standard lengths flexible, ¾ to 2 in., 50 ft.

Locknuts and Bushings—Following are net prices in New York in standard packages, which are: ½ in., 1,000; ¾ to 1¼ in., 100; 1½ to 2 in., 50:

In.	Locknuts Per 100	Bushings Per 100	Flexible Conduit Box Connections Per 100
½	$1.02	$1.68	$5.62
¾	1.75	4.00	7.12
1	3.00	6.15	10.50
1¼	5.00	8.20	15.00
1½	7.50	10 25	22 50
2	10.00	16.40	30 00
2½	12.30	24.60	67.50

Armored Cables and Box Connectors—Following are net prices in New York per 1,000 ft. cable and standard package of 100 box connectors in single and double strip:

	Twin Conductor		Three Conductor	
Wire Gage	Cable	Connectors	Cable	Connectors
14	$75.00	$4.50	$106.26	$4.50
12	103.95	4.50	130.90	4.50
10	142.45	4.50	180.95	4.50
8	180.95	4.50	250.25	5.70
6	284.90	5.70	363.44	8.10
4	442.75	8.40	....	....

Lamps—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs				Pear-Shape Bulbs		
Mazda B—			No. in	Mazda C—		No. in
Watts	Plain	Frosted	Package	Watts	Clear	Frosted	Package
10	$0.27	$0.30	100	75	$0.65	$0.70	..
15	27	.30	100	100	1.00	1.05	24
25	.27	.30	100	300	3.00	3.10	24
40	.27	.30	100	500	4.50	4.65	12
50	.27	.30	100	750	6.00	6.25	8
60	.36	.40	100	1,000	7.00	7.25	8

Standard package quantities are 10% from above prices. Yearly contracts ranging from $150 up allow a discount of 17% from list.

MISCELLANEOUS

Hose—

Fire	50-Ft. Lengths
Underwriters', 2½-in.	60c. per ft.
Common, 2½-in.	50-10%

Air	First Grade	Second Grade	Third Grade
¾-in., per ft.	$0.50	$0.28	$0.20

Steam—Discounts from list

First grade.... 30% Second grade.... 30-5% Third grade.... 40-10%

Rubber Belting—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50-10% Best grade 25%
Standard 40-10%

Leather Belting—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40—5%	35—5%
St. Louis	40—5%	40%
Chicago	45—5%	35—10%

Rawhide Lacing—40%.

Packing—Below are prices each in cities named per pound:

Asbestos

		New York	Chicago
Valve and Stuffing Box	Twisted plain, 25-lb. cartons	$0 65@0.70	$0.80
	Twisted graphite, 25-lb. cartons	.80	.90
	Braided plain, 25-lb. cartons	.90	1 00
	Braided graphite, 25-lb. cartons	1.00	1.10

Asbestos wick in balls, ¼-, ½-, 1-, 25- and 50-lb. cartons, $0.65@0.70, New York; $0.80, Chicago.

Rubber asbestos, compressed sheets, medium grade about $0.80, New York; $0.93, Chicago.

Steam

Following in 25- and 50-lb. cartons:

First grade	$0 83	Second grade	$0.55

Rubber and Duck

Higher grade	$0.44	Cold water	$0 28

Piston

Asbestos, duck and rubber	$1.38	Rubber and duck	$0.99
Flax first grade	.94		

Pipe and Boiler Covering—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard Thickness Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in	.30
3-in.	.45	1½-in.	.45
4-in.	.60	2 -in.	.60
6-in.	.80	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... 15% off

Air cells for low-pressure heating and return lines: 4-ply ..... 58% off; 3-ply ..... 60% off; 2-ply ..... 62% off

Greases—Prices are as follows in the following cities in cents per pound for bbl lots:

	New York	Chicago	St. Louis
Cup	5@7	6	4⅝
Fiber or sponge	5@7	6¼	5⅝
Transmission	5@7	6¼	5⅝
Axle	3@4	3½	3 1/10
Gear	4@5	5	3
Car journal (S. & F.)	6½	4½	9½

Cotton Waste—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Apr. 25, 1917	One Year Ago		
White	13.00@15.00	11.00@13.00	12.50@14.00	13.00@15.00
Colored Mixed	10.00@12.00	8.00@10.00	8.50@12.00	10.00@12.00

Wiping Cloths—In Cleveland the jobbers' price per 1,000 is as follows:

13¼x13¼ ..... $35.00 13¼x20½ $45.00

In Chicago they sell at $30@33 per 1,000.

Manila Rope—Price per lb. in 1,200-ft. coils, New York:

	Ft. per Lb.			Ft. per Lb.	
⅞-in.	8	$0.24½	1 -in.	3 ft. 6 in.	$0.24½
¾-in.	6	.24½	1⅛-in.	2 ft. 10 in.	.24½
⅞-in.	4 ft. 6 in.	.24½	1¼-in.	2 ft. 4 in.	.24½

Sizes smaller than ⅝-in. from ½ to 2c. extra per lb. Extra charge of 1c. per lb. for less than 600 ft.

Ammonia—Below are prices per lb. in cities named:

	St. Louis	New York
26° U.S.P carboys of 100 lb.	...*	6¼c.
26° U.S.P. drums of 1000 lb.	5¾c.	5½c.

*Not used here. Anhydrous ammonia in 100-lb. cylinders costs 25c. per lb., in St. Louis.

Linseed Oil—These prices are per gallon:

	New York		Cleveland		Chicago		St. Louis
	Apr. 25, 1917	Six Months Ago	Apr. 25, 1917	Six Months Ago	Apr. 25, 1917	Six Months Ago	Apr. 25, 1917
Raw in barrels	$1.19	$0.88	$1.25	$0.87	$1.11	$0 82	$1.12
5-gal. cans	1.20	.98	1.35	.97	1.21	.92	...

Boiled, 1c. per gal. additional.

White and Red Lead, in cents per pound, as follows:

	Red				White			
	Apr 25, 1917		6 Months Ago		Apr. 25, 1917		6 Months Ago	
	Dry	In Oil	Dry	In Oil	Dry	and In Oil	Dry	and In Oil
100-lb. keg	11.25	11.50	10.50	11.00	11.00		10.50	
25- and 50-lb. kegs	11.50	11.75	10.75	11.25	11.25		10.75	
12½-lb keg	11.75	12 00	11.00	11.50	11.50		11.00	
1- to 5-lb. cans	13.25	13.50	12.50	12.50	13.00		12.50	

Fire Brick—Quotations on the different kinds in the cities named are as follows f.o.b. works:

	New York	Joliet, Ill.	St. Louis
Silica brick, per 1000	$40.00@50.00	$50.50	$50.00
Fire clay brick, per 1000, No. 1	35.00@45.00	35 00@50.00	45.00
Magnesite brick, per net ton	140.00	135.00	....
Chrome brick, per net ton	135.00	135.00	....
Deadburned magnesite brick, per net ton	85.00@90.00	85.00	....
Special furnace chrome brick, per net ton	60.00@70.00	60.00@70.00	....

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

Fuel Oil—Price in cents per gal., in the following cities in bbl. lots:

	New York	Chicago	St. Louis
Domestic light, 22-26 Baumé	7	4½	8½
Mexican heavy, 12-14 Baumé	6	5⅛	...

Chicago f.o b.

Poles—The prices on Western red cedar poles, effective Dec. 21, 1916:

	New York	Chicago	St. Louis	Denver
6 in. by 30 ft.	$5.24	$4.59	$4.59	$3.97
7 in by 30 ft.	6.90	6.10	6.10	5.30
7 in by 35 ft.	9.70	8.60	8.60	7.55
8 in. by 35 ft.	11.20	9.90	9.90	8.65
7 in. by 40 ft.	11.35	10 00	10.00	8 75
8 in. by 40 ft.	12.75	11.15	11.15	9.65
8 in. by 45 ft.	15.70	13.70	13.70	11.80
8 in by 50 ft.	18.35	15.95	15.95	13.65

Portland Cement—These prices are for barrels in carload lots, including bags:

	Apr. 25, 1917	One Month Ago	One Year Ago
New York	$2.12	$1.97	$1.27
Jersey City	2.00	1.85	1.21
Boston	2.20	2.17	1.47
Chicago	2 16	1.96	1.36
Pittsburgh	2.16	2.06	1.36
Cleveland	2.29	2.19	1.50
Detroit	2.25	2.15	1.45
Indianapolis	2 29	2.19	1.49
Toledo	2.29	2 15	1.49
Milwaukee	2.28	2.08	1.48
Minneapolis	2.43	2.23	1.63
Duluth	2.41	2.21	1.56
Peoria	2.28	2.08	1.44
Cedar Rapids	2.39	2 19	1.55
Davenport	2.34	2.14	1.45
St. Louis	2.20	1.95	1.40
San Francisco	2.60	2.30	1 90

Pipe—The following discounts are for carload lots f.o b. Pittsburgh, basing card in effect Apr. 1, 1917:

BUTT WELD

Steel			Iron		
Inches	Black	Galvanized	Inches	Black	Galvanized
⅛, ¼ and ⅜	48%	21½%	¾ to 1½	44%	28%
½	52%	37½%			
¾ to 3	55%	41½%			

LAP WELD

2	48%	35½%	1¼	29%	14%
2½ to 6	51%	38½%	1½	36%	22%
			2	37%	23%
			2½ to 4	39%	26%
			4½ to 6	39%	26%

BUTT WELD. EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	44%	26½%	¾ to 1½	49%	29%
½	49%	36½%			
¾ to 1½	53%	40½%			
2 to 3	54%	41½%			

LAP WELD. EXTRA STRONG PLAIN ENDS

2	46%	34½%	1¼	30%	15%
2½ to 4	49%	37½%	1½	36%	22%
4½ to 6	48%	36½%	2	38%	25%
			2¼ to 4	40%	28%
			4½ to 6	39%	27%

Following discounts are for carload lots f.o.b. warehouse in cities named:

	New York		Cleveland		Chicago	
	Black	Galvanized	Black	Galvanized	Black	Galvanized
¾ to 3 in. steel butt welded	44%	28%	49%	34%	49%	49%
3½ to 6 in. steel lap welded	36%	18%	45%	31%	34%	34%

Malleable fittings, Class B and C, from New York stock sell at 50 and 5% from list price. Cast iron, standard sizes, 34 and 5%.

Boiler Tubes—Discounts on less than carloads from Pittsburgh, freight to be added, effective from Nov. 1, 1916, except 3 to 4½ in. steel from Nov. 20, are as follows:

Lap Welded Steel		Standard Charcoal Iron	
1¾ and 2 in.	31%	1½ in.	23%
2¼ in	28%	1¾ and 2 in.	35%
2½ and 2¾ in.	34%	2¼ in.	32%
3 and 3½ in.	34%	2½ and 2¾ in.	38%
3½ to 4½ in.	34%	3 and 3¼ in.	43%
5 and 6 in.	33%	3½ to 4½ in.	....
7 to 13 in.	30%	5 and 6 in.	37%
		7 to 13 in.	34%

Locomotive and steamship special charcoal grades bring higher prices. 1¾ in., over 18 ft. and not exceeding 22 ft., 10% net extra. 2 in. and larger, over 22 ft., 10% net extra.

Cast-Iron Pipe—The following are prices per net ton for carload lots:

	New York					cisco	Dallas
	Apr. 25, 1917	1 Mo. Ago	One Year Ago	Birmingham	Chicago	Fran- San	
4 in.	$58 50	$44 50	$34.00	$53.00	$58.50	$59.00	$65.00
6 in. and over	55.50	41.50	29.50	50.00	55.50	56.00	62.00

Gas pipe and 16-ft. lengths are $1 per ton extra.

Cold Drawn Steel Shafting—From warehouse to consumers requiring fair-size lots, the following quotations hold:

	Jan. 30, 1917	Six Months Ago
New York	List plus 25%	List plus 20%
Cleveland	List plus 10%	List plus 20%
Chicago	List plus 5%	List price